DOCUMENT RESUME

ED 287 743 SE 048 707

| | |
|---|---|
| TITLE | Science Framework, Kindergarten-Grade 12. |
| INSTITUTION | Texas Education Agency, Austin. Div. of Curriculum Development. |
| REPORT NO | CU-370-07 |
| PUB DATE | 87 |
| NOTE | 157p. |
| AVAILABLE FROM | Publications Distribution Office, Texas Education Agency, 1701 N. Congress Avenue, Austin, TX 78701-1494 ($4.00). |
| PUB TYPE | Guides - Classroom Use - Guides (For Teachers) (052) -- Guides - Non-Classroom Use (055) |
| EDRS PRICE | MF01/PC07 Plus Postage. |
| DESCRIPTORS | Bilingual Education; Course Content; *Course Descriptions; *Elementary School Science; Elementary Secondary Education; Experiential Learning; Gifted; *Science Curriculum; Science Education; Science Equipment; *Science Instruction; *Secondary School Science; Special Education; *State Curriculum Guides; State Programs |
| IDENTIFIERS | *Texas |

ABSTRACT

This publication is designed to aid school administrators, curriculum planners, and teachers in implementing the science education program in Texas public schools. The framework organizes instruction for kindergarten through grade 12 around certain widely accepted processes of science. These processes are reflected in the identified essential elements of instruction the State Board of Education requires school districts to offer. Each essential element has subelements that provide content for particular grades and courses. The essential elements and subelements provide opportunities for students to be involved in concrete activities in kindergarten through grade 6 and in laboratory and field activities in grades 7-12. In addition, the framework encompasses science programs for special student populations, including special education, gifted and talented education, compensatory education, bilingual education, and migrant education. The document is divided into four major sections: Overview of the Science Program, Elementary Science, Secondary Science, and Special Student Populations and Science. The appendices contain examples of alternative assessment procedures and basic materials and equipment lists. (TW)

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# SCIENCE FRAMEWORK
## KINDERGARTEN – GRADE 12

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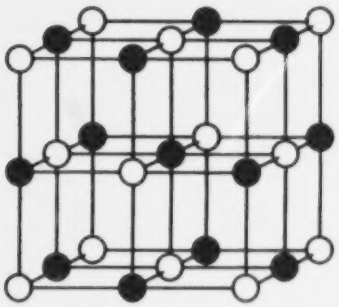

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# Foreword

This publication, *Science Framework, Kindergarten-Grade 12,* is designed to aid school administrators, curriculum planners, and teachers in implementing the science education program in Texas public schools. The framework organizes instruction for kindergarten through Grade 12 around certain widely accepted processes of science. These processes are reflected in the identified essential elements of instruction the State Board of Education requires school districts to offer. Each essential element has subelements that provide content for particular grades and courses. The essential elements and subelements provide opportunities for students to be involved in concrete activities in kindergarten through Grade 6 and in laboratory and field activities in Grades 7-12.

We hope this publication will help school district personnel plan and implement activity-oriented science programs that will stimulate students' interest in science and technology.

W. N. Kirby

Commissioner of Education

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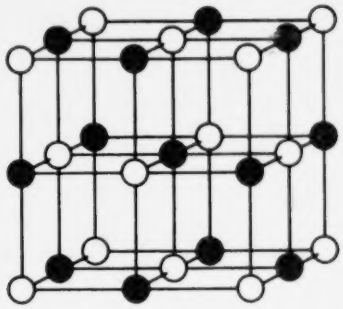
# Overview of the Science Program



# Introduction

The science program presented by this framework reflects the major revision of the state's public school curriculum mandated by legislation beginning in 1981. In an attempt to improve student achievement by upgrading the curriculum, the 67th Legislature in '81 amended the Texas Education Code through House Bill 246. The bill required that a standard, well-balanced curriculum, including science, be taught across the state.

Passage of HB 246 reflected widespread concern about curriculum. Curriculum inadequacies had been evidenced by poor student achievement on such test measurements as the Scholastic Aptitude Test (SAT) and the Texas Assessment of Basic Skills, now called Texas Educational Assessment of Minimal Skills (TEAMS).

The curriculum had become overcrowded with a variety of topics, creating confusion and uncertainty about what was of critical importance for teachers to teach and for students to learn. Content covered varied considerably from district to district, campus to campus, and classroom to classroom. Educators feared that wide variations in the curriculum limited a highly mobile student population's access to a basic and consistent curriculum.

These concerns had caused the 66th Legislature to direct the State Board of Education to undertake a curriculum study in 1979. The Board recommended to the 67th Legislature that all schools should be required to offer a well-balanced curriculum and that the most essential parts of each subject and course be designated. A Governor's Advisory Committee on Education supported the Board's recommendation. Passage of HB 246 was the legislative result of these actions.

Today, provisions of HB 246 begin with Section 21.101 of the Texas Education Code. The State Board rules for implementing the law are contained in Title 19, Chapter 75 of the Texas Administrative Code. These rules state that:

> "(a) Each school district . . . shall offer a well-balanced curriculum that includes . . . science. . . ."
>
> "(c) The State Board of Education by rule shall designate the essential elements of each subject . . . and shall require each district to provide instructions in those essential elements at appropriate grade levels."

The essential elements are defined as the core areas of concepts and skills that must be included in instruction and that each student must be provided an opportunity to learn.

To implement the law, the State Board of Education involved Texas educators, policymakers, and the public in regional groups that met throughout the state to identify the essential elements of the subject areas specified in the law. Curriculum study groups also recommended subelements to give more specificity to the essential elements. The recommendations were reviewed by advisory groups and were discussed in a series of public meetings. In 1984, the Board approved the essential elements now listed in Chapter 75. The essential elements were first implemented in the 1985-86 school year.

Periodically, some members of the original regional groups will be called upon to monitor the effectiveness of the curriculum. A review in Spring 1986, for example, found that the Chapter 75 science curriculum better balances the elementary and secondary programs than did the former program.

This curriculum framework is designed to help school district educators implement the Chapter 75 science program in a way that is realistic in its aims, yet challenges students to strive for educational excellence.

# Science Education for Texas

Science offers possible solutions to many of the challenges that confront society today. In Texas, these challenges include those related to energy, technology, ocean and space exploration, water and other resources, ecology, health and medicine, and communication and electronics.

In the face of these challenges, Texas students must develop scientific literacy. With scientific literacy, they will:

- have a knowledge base of facts, concepts, and process skills which enable them to continue to learn and think logically throughout their lives
- continue to use their resources to access information
- recognize the benefits as well as the limitations of science in advancing human progress
- understand the applications of technology and assume the responsibility of decisions relating to technology
- recognize the consequences of their own and society's actions
- realize the dynamic nature of science as evidence continues to accumulate

The development of students' scientific literacy is a purpose of the Chapter 75 science program. The program provides essential elements of instruction that give students opportunities to develop skills necessary to gain concepts and solve problems related to science throughout their lives.

In the past, science instruction traditionally emphasized the acquisition of facts. However, facts may become obsolete as the body of scientific knowledge progresses through new frontiers. Therefore, an emphasis on learning content provides a limited science foundation for students who will soon be entering the 21st century.

In today's program, students both learn content and develop skills, enabling them to deal effectively with science-related challenges. A foundation of concrete experiences that will help students acquire abstract concepts is provided by:

- the essential elements which reflect processes widely used by scientists
- an elementary science program that provides a balance of content and activities
- a secondary program that provides laboratory-oriented instruction

Overall, the Chapter 75 science program emphasizes active student involvement with materials, fellow students, the environment, and other resources. In an atmosphere of inquiry, the teacher becomes a facilitator who guides the students' investigations rather than a disseminator of information as in the past. Textbooks become only one resource from which students may draw information. Laboratory investigations promote hypothesizing, stimulate individual interests, and strengthen concept development. Districts and campuses address students' individual differences by providing a supportive atmosphere in which students and teachers may be enthusiastic, imaginative, and intellectually stimulated.

Science essential elements begin in kindergarten by addressing four basic skills. Additional essential elements for other skills are accumulated through Grade 6; then, these 9 essential elements are carried into secondary courses. In this way, kindergarten and elementary students begin to develop skills that will be further honed by secondary science courses. In providing opportunities for students to acquire these skills, the science program helps them become thinking individuals, problem solvers, and contributing citizens.

# Goals of the Science Program

The goals of the science program, K-Grade 12, help students prepare for life in a technology-based future. They encompass five facets of student preparation. The goals are:

- to increase students' conceptual base of scientific phenomena. An understanding of science will nurture students' sense of interrelatedness with their environment.
- to promote students' abilities to think critically to find solutions to problems. Scientific investigation is conducted through use of a series of process skills. Practice in the process skills assists students in learning to make inferences.
- to foster students' comfort with technological advances. Through limited access to and understanding of technological innovations, students will gain insights concerning the applications of science.
- to develop students' attitudes toward and appreciation for the uses, benefits, and limitations of science in our society
- to develop students' awareness of career opportunities in science

# The Science Continuum

## Defining the Essential Elements

The science essential elements provide for students' development of a continuum of skills, kindergarten through Grade 12. A skill that is introduced in kindergarten is taught each year within new contexts and to greater sophistication. The skills are designed to stimulate the students to investigate their environment; solve problems through inquiry; recognize the relationships of science, technology, and society; and enjoy learning throughout their lives.

To develop the skills, students take an active part in learning. They rely on their own inventiveness, curiosity, and talents to gain concepts.

### Essential Element 1: Manipulative Laboratory Skills

Students develop eye-hand coordination in doing science activities safely. For example, in kindergarten, students string beads according to various characteristics, pour sand and water, experience various textures, and do other activities. In other elementary grades, students manipulate objects of their own construction, objects which are commercially available, objects from the environment, and devices that enable students to take measurements.

In junior high and high school, manipulations focus on laboratory techniques and use of equipment specific to the course. School districts are required to provide laboratory equipment and appropriate work space for the students. As in the elementary grades, safety is emphasized.

### Essential Element 2: The Use of Skills in Acquiring Data Through the Senses

Students are encouraged to use all the senses to observe phenomena. In kindergarten, they observe their immediate surroundings in an attempt to recognize their senses, their sense organs, and similarities and differences in objects in their environment. The primary grades are excellent years to stimulate the senses and to teach science through activities that use food. In observance of safety practices, subsequent grades will limit the use of the sense of taste and smell. Intermediate students expand their skills by observing phenomena over a period of time. Microscopes, models, simple machines, and living specimens are all used to aid students' observations. Students also expand their observations to include their communities.

At the secondary level, students use sophisticated apparatus unique to each course to make observations. Also, districts allow students the opportunities to observe on the school campus, in the community, and at points of interest within the state relevant to the course. Observations increase in abstraction at successive grades.

### Essential Element 3: The Use of Classification Skills in Ordering and Sequencing Data

Primary students classify objects from their environment. Asked to communicate their rationale for a particular scheme, the child may answer, "These objects I like; these objects I don't like." The teacher accepts this answer and then designs activities to further develop the child's concepts.

Students sequence activities of their daily lives. Intermediate students are guided by the teacher to design more elaborate classification schemes and to interpret simple classification keys.

Secondary students order and sequence data to make the information meaningful. They design dicotymous keys, group elements by valence electrons, and sequence the steps in experimental in-

vestigations to test a hypothesis. Students sometimes classify abstract data such as numerical measurements, and they organize abstract concepts into meaningful models and principles.

## Essential Element 4: Experience in Oral and Written Communication of Data in Appropriate Form

For primary students, teachers provide experiences on which students build oral language communication and create opportunities for students to share those experiences. In written communication, students mark their heights on a life-sized bar graph, for example.

Intermediate students also share their experiences, interpret their data, report orally, and describe phenomena. They display their data on tables, graphs, charts, and histograms.

In Grades 7-12, students describe, interpret, explain, compare/contrast with the intent of conveying meaningful data. They record the data obtained in their group, share data among groups, design methods to display their data graphically, and report orally and in written form.

## Essential Element 5: Experience in Concepts and Skills Of Measurement Using Relationships to Standards

This essential element is introduced in Grade 1. The key to the element is that students make measurements in relation to a standard. In Grade 1, students may string paperclips together. They measure the height of their chairs and desks in paperclips. If all the students are using spoons as the measuring device, then spoons are the standard. Toward the end of Grade 1 and throughout their school career, students use a metric system for measurement.

Secondary students use sophisticated measuring devices such as burets, pipets, analytical balances, graduated cylinders, volumetric flasks, astrolabes, and the meter stick to standardize and quantify observations.

## Essential Element 6: The Use of Skills in Drawing Logical Inferences, Predicting Outcomes, and Forming Generalized Statements

This essential element is introduced in Grade 2. The teacher's questioning strategies play a vital role in helping students develop the skills named in this element. The teacher asks, "if-then" and "cause-and-effect" questions. Questions that ask "What might happen if. . .?" and "What do you think caused. . .?" help students make predictions and inferences. When asked to describe the phenomena they have witnessed in the activity, students form generalized statements.

Secondary students are asked to predict phenomena based upon knowledge of earlier concepts and principles and to make inferences based on their data.

## Essential Element 7: Experience in Skills in Relating Objects and Events to Other Objects and Events

Concepts presented in the classroom are small examples that reflect a larger world. For example, maintaining animals in the classroom can be related to maintaining pets at home, wild specimens in zoos, and livestock on ranches and farms.

The essential element, which is introduced in Grade 4, also offers opportunities for reteaching, remediating, and enriching as students relate the experiences and experiments of one instance to other experiences and experiments.

## Essential Element 8: Experience in Applying Defined Terms Based on Observations

Introduced in Grade 4, this essential element calls for students to begin to apply some of the technical terms that describe the phenomenon they have experienced. Scientific terms are not too technical if students have had experiences on which to base definitions.

In secondary science, students form operational definitions that require concepts to be defined in terms of the operations which describe them. A statement that compares the properties of objects or events can also be an operational definition.

## Essential Element 9: Experience in Identifying and Manipulating the Conditions of Investigations

At the heart of science is the experiment. This essential element, introduced in Grade 5, provides opportunities for elementary and secondary students to understand the nature of variables in the investigations. As students work in small groups, one group may act as the control group while the other groups manipulate one or more variables. Students share data at the end of the class.

Teachers give secondary students increased independence and responsibility in the design and execution of experiments. Students control and manipulate variables within each experimental design. They, too, share their findings.

## Essential Element 10: Application of Science in Daily Life

In this essential element, which is introduced in Grade 7, students are given opportunities to explore the relevance of science and technology to their daily lives. They research current topics specific to the course and discuss career opportunities.

## Essential Element 11: Health Concepts and Skills

During each semester of Life Science, students study three weeks of health education. They investigate first aid; communicable and noncommunicable diseases; the relationship of alcohol, tobacco, marijuana, and other drugs to personal health; and regulations concerning drug use.

## Additional Essential Elements: For Introductory Biology And Introductory Physical Science

There are four essential elements for the consumer applied-science courses: Introductory Biology and Introductory Physical Science.

1. Manipulative skills. Students are required to devote 40 percent of the instructional time to laboratory activities.
2. Rational thinking skills. This essential element collapses the scientific processes and promotes problem solving, higher level thinking skills, and creativity.
3. Scientific knowledge. Content for Introductory Biology and Introductory Physical Science focuses on personal goals, career opportunities, technological advances, recreational and avocational activities, and societal issues.
4. Applications of science. Students apply to their lives lessons learned and classroom activities performed.

# Implementing the Essential Elements in Sample Lessons

## Coordinated Presentation

The science essential elements may also be thought of as a continuum in that each essential element is taught in concert with every other essential element. For example, students **manipulate;** however, they manipulate to **acquire data through their senses.** They **communicate their data orally** by sharing ideas among group members and by contributing to class discussions. They **communicate their data in an appropriate written form** on tables, graphs, charts, and in reports.

Students **classify** their materials according to some characteristics and their data according to a scheme. They may take **measurements** to refine their information. Before all the data are in, students **make predictions** as to the outcome of the study. Once members of a group or class collaborate their data, **inferences** are drawn. Students are able to discuss in **generalized statements** what is occurring within the study.

The class **relates the objects and events of the experiment to other objects and events.** Students may relate the experiment to further experimentation or to life situations. They **apply defined terms based on their observations** of the phenomena occurring during the experiment. To ensure that experimentation is taking place, students **identify the variables** that affect the outcome. Then they **manipulate one or more variables while holding the other variables constant.** Students **apply the study to their daily lives.** The teacher makes every lesson relevant to the students' lives.

Although in each science lesson the teacher will attempt to teach the target subelement in concert with all of the essential elements, not every lesson will lend itself to using all other essential elements. Lesson objectives will determine the depth to which the essential elements are explored and the sequence and number of the essential elements used during the lesson.

## Sample Lessons

The following sample lessons are for Grades 1 and 4, Earth Science, and Physical Science. The lessons illustrate how the teacher may incorporate all the essential elements in the lesson.

## Grade 1

### Target subelement: 4.D Name the senses

Related essential elements and student activities:

1. Manipulative laboratory skills. Students pour out the correct amount of popcorn and oil.
2. Acquire data through the senses. Students observe the odors emitted as the kernels pop. They hear the popping sounds. They see the changes that occur as heat is added to the corn. Once the popcorn has cooled, students serve cups of popped corn to class members. They eat it, tasting the corn and the salt, feeling the heat and the oil, smelling the unique odors.
3. Classification skills. Students classify the sensations they have experienced according to the sense organs.
4. Communication:
   - Oral communication. Students verbalize their reactions to the corn as it is popping and as they handle and eat it.
   - Written communication. Students draw ears, eyes, a tongue, and a nose on an outline of a head.
5. Skills in measurement. Students measure the correct amount of popcorn and oil.

## Grade 4

### Target subelement: 1.A Use magnets

Related essential elements and student activity:

1. Manipulative laboratory skills. Students manipulate various types of magnets, iron filings, magnetic and nonmagnetic objects.
2. Acquire data through the senses. Students observe the behavior of magnets and magnetic fields.
3. Classification skills. Students classify objects as being attracted or not to magnetic forces and the poles of magnets.
4. Communication:
   - Oral communication. Students discuss with their groups the design of their experimentation, and report orally to the class.

- Written communication. Students illustrate the magnetic fields they observe around the various types of magnets.

5. Skills in measurement. Students compare the magnetic strengths of different magnets according to the amount of iron filings by weight they attract or the number of paper clips they pick up.
6. Infer, predict, and form generalized statements. Based on their experiences with magnets attracting and repelling objects, students predict the shape of the magnetic fields prior to sprinkling the iron filings. After they manipulate the magnets and iron filings, students infer that the shapes are based on the magnetic poles. They form generalized statements regarding the behaviors of like and unlike poles.
7. Relate objects and events to other objects and events. Students research the magnetic fields of the earth.
8. Apply defined terms based on observations. Students form working definitions of **poles, magnetic fields, attract, repel.**

## Earth Science

### Target subelement: 7.D Contrast human activities that affect the natural environment

Related essential elements and student activity:

1. Manipulative laboratory skills. Students collect the litter on their campus for one week.
2. Acquire data through the senses. Students observe the prime locations of litter and observe the days of greatest litter. Photographs are taken, processed, and displayed depicting the worst scenes.
3. Classification skills. Students separate litter according to recyclable, returnable, and trash.
4. Oral and written communication. Students design their study, interact as they find solutions, and report orally regarding their findings. Written communication includes tables of data, graphs, charts, antilitter campaign posters, and the final written report of the students' conclusions.
5. Measurement. In this lesson, litter is weighed in grams.
6. Inferences and predictions. Prior to the study, students make predictions concerning which day of the week will be the worst litter day and which areas of the campus are the heaviest littered. Once collection of the data is completed, students make inferences or conclusions.
7. Relate objects and events to other objects and events. Litter on the school campus represents a small part of a greater, global problem. Students explore pollution in all its forms. They make excursions to land fills to examine litter, waste water treatment plants to examine water pollution, airports and highways to record noise pollution, industrial sites to witness air pollution.
8. Apply defined terms based on observations. Students develop working definitions of **litter, pollution, personal responsibility, environmental impact.**
9. Identifying and manipulating the conditions of investigations. The study is replicated before and after the students' anti-litter campaign.
10. Applications to daily life. Students discuss their responsibilities as individuals in maintaining a beautiful and healthy community and state.

## Physical Science

### Target subelement: 10.A Analyze the use of chemicals in everyday activities of the home and industry

Related essential elements:

1. Manipulative laboratory skills. Students test the effectiveness of five cleaning compounds using a variety of manipulative laboratory skills.

2. Skills in acquiring data through the senses. Using their senses, students observe the characteristics of five selected cleaning compounds. Safety is emphasized. Students wear chemical, splash-proof eye goggles and lab aprons. The laboratory is adequately ventilated.
3. Classification skills in ordering and sequencing data. Following the testing of five cleaning compounds for effectiveness, students order the cleaning compounds from most effective to least effective.
4. Oral and written communication of data. Students record their observations of the characteristics of the cleaning compounds and their cleaning abilities in a table and present their findings orally to the class.
5. Concepts and skills of measurement. To compare the effectiveness of various cleaning compounds, students measure in grams equal amounts of the compounds. They apply the samples to stains and record the time it takes for the cleaner to remove the stain.
6. Skills in drawing logical inferences, predicting outcomes, and forming generalized statements. From the cleaning effectiveness data collected, students conclude which cleaner is the most effective on the particular stain used in the test.
7. Relating objects and events to other objects and events. Students compare the cleaning effect of liquid cleansers to solid cleansers.
8. Applying defined terms based on observations. Students develop working definitions of **cleaning solvent, detergent, abrasive.**
9. Identifying and manipulating the conditions of investigations. Students design an experiment to test the effectiveness of five cleaning compounds.
10. Application of science to daily life. Students compute the cost effectiveness of the cleaning compounds tested.

# Science Laboratory Instruction

State Board rules specify that science courses in Grades 7-12 shall devote a minimum of 40 percent of the instructional time to student laboratory/field activities. In the secondary sciences, laboratory instruction has several important functions. It provides the means for introducing students to abstract ideas through concrete experiences. Research indicates that when a concept is presented in concrete terms, understanding of that concept is enhanced for students in all stages of cognitive development. Manipulative experiences are especially important for students still operating in the concrete stage. Teachers can present concepts in concrete form by simply involving students in three-dimensional model building exercises, in introductory activities emphasizing fact gathering and generalizing, and in activities verifying a concept or principle.

In Grades 9-12, teacher demonstration is not considered laboratory/field activity although it is an important part of the teaching of science. The 40 percent of instructional time devoted to laboratory/field activities should be a cumulative average for the course. There is no need for concern that certain units do not lend themselves to laboratory activities, because other units will require more than 40 percent laboratory time to be taught effectively. For example, in Chemistry I, atomic structure is a unit that does not lend itself to 40 percent laboratory time. However, the time will be made up during the unit on gas laws which may require a large percentage of laboratory time. The percentage of laboratory time should be based upon the time allotted to prelaboratory activities, the actual laboratory activity, and postlaboratory analysis.

With regard to field studies, the time that students are actually engaged on site is considered part of the 40 percent instructional time. Travel time may or may not constitute a portion of the laboratory/field time. If the students are academically engaged during the travel time, it may count toward the 40 percent time requirement. For example, while walking to a campus area for fieldwork, students may be asked to identify species of plants noted along the way. This activity would be considered academically engaged time and would constitute a portion of the 40 percent. Teachers are encouraged to make use of the school campus and surrounding natural areas for providing a variety of opportunities for students to practice science process skills—observing, measuring, classifying, communicating, making inferences and predictions, and experimenting. Local community resources should be used also. For example, museums, zoological parks and aquaria, humane shelters, energy generating plants, waste water treatment plants, planetaria, and private industry have educational programs that relate to science lessons.

Students' using computers instead of doing actual activities in science laboratory raises questions in regard to the 40 percent rule. Computer activity may be considered laboratory time if it is a simulation of an actual activity not easily conducted because of safety, equipment concerns, or time factors. Computer interphasing with measurement devices (i.e., temperature probes, pH probes) would be considered a laboratory activity as long as every student or small group is responsible for obtaining data from the computer-managed equipment. The teacher's use of the computer program as an introductory activity or demonstration and students' use in drill and practice would not be considered laboratory activities.

## Types of Laboratory Activities

There are several types of laboratory activities that emphasize different skills and objectives. Teachers of quality laboratory courses use each type of activity as appropriate. Types of laboratory activities include:

- **verification activities**
  These activities allow students to experience abstract concepts and phenomena in a concrete manner. Verification activities follow the initial presentation of the concept. For example, after an explanation of Boyle's law, the students observe the relationship in the laboratory.
- **guided inquiry activities**
  These activities allow students to determine relationships in their data and to draw their own conclusions. Students do not know the results of the activity prior to conducting it. Guided inquiry activities precede the presentation of the concept. For example, students collect volume data as they vary the pressure of a gas and draw a conclusion about the relationship from their data.

- **inquiry activities**
  There are two categories of inquiry activities—teacher-initiated and student-initiated. In the teacher-initiated inquiry activity, the teacher presents students with a problem; the students are expected to develop research designs to test a hypothesis related to the problem. In the student-initiated activity, the student is expected to isolate the problem and develop the research design to test a formulated hypothesis.

- **exploratory activities**
  These activities allow students to observe and describe new materials and phenomena prior to receiving instruction. For example, students are asked to observe various protozoans and describe their movement. Exploratory activities tend to be unstructured with no specific procedure and require only a few minutes to complete.

- **skill development activities**
  These activities have as their major objective the teaching of a manipulative laboratory skill. For example, an activity in which the student weighs various objects using a triple-beam balance teaches a skill. These skills may be integrated with another type of activity. However, this forces the student to focus on two separate activities simultaneously. Complex skills are best taught separately from concepts.

- **process development activities**
  These activities provide opportunities for students to practice process skills and problem solving. For example, an activity in which the student makes a prediction and then tests that prediction facilitates the skill of predicting. Activities should be provided that allow students to practice all of the process skills reflected in the essential elements.

## Lesson Planning for Laboratory Activities

Lesson planning for laboratory instruction is crucial because the design of the activity determines objectives to be taught. Different types of activities such as verification, skill development, and inquiry emphasize different skill areas. For example, a teacher would plan a guided inquiry activity if an objective was to teach students to formulate a hypothesis. A verification activity would not be appropriate since verification activities follow the presentation of a concept and the outcome of the activity is known.

Teachers will find it helpful to plan laboratory/field activities using a prelaboratory, laboratory, and postlaboratory sequence. Prelaboratory instruction prepares the student for optimum involvement in the laboratory activity. Mixing reagents and setting up glassware and apparatuses are examples of prelaboratory activities. General safety reminders should be given and specific safety concerns should always be discussed during prelaboratory instruction. The prelaboratory phase requires various amounts of instructional time depending on the type of activity. For example, an exploratory activity requires a minimum amount of information be given the student. For a skill development activity, more information and modeling of the skill is needed prior to learning the skill.

The second phase, laboratory activity, involves students in the problem-solving process or provides concrete verification for a concept or principle. All types of laboratory activities should be used.

The third phase, postlaboratory, provides a culminating experience for the laboratory/field activity in a variety of forms such as discussions, individual or class data analysis, student presentation of data and conclusions, and formal laboratory reports. The meaning and implications of the laboratory activity are emphasized during this phase, and logical extensions and applications are suggested or discussed.

# Computer Applications in The Science Curriculum

Computer technology's place in the science curriculum is to assist in the delivery of instruction, to serve as a tool for students in science, and to provide teachers a tool for classroom management. Depending on the amount of equipment available, computers can be used in a variety of instructional roles. Tutorial courseware may assist in concept instruction, drill and practice courseware helps students practice skills and drill on factual information, and simulation programs allow students to conduct inquiry investigations within restricted environments.

## Computer-Assisted Instruction

The computer's capabilities to offer individualized instruction can help the teacher meet the instructional needs of a broad range of science students. Unfortunately, this also implies a small student-to-computer ratio, a luxury many science classrooms in Texas do not have. However, there is a variety of computer-assisted instruction (CAI) software on the market that may be used effectively even with one computer in the classroom. Often this necessitates a demonstration mode with the computer situated at the front of the room with a large monitor. For example, the teacher may use simulations to lead the class in an inquiry discussion, asking "what if. . ?" while students direct manipulation of the simulated variables. Software used in this manner should make use of graphics that are easily visible for the participating students.

## Student Tool Applications

The computer can be used effectively in the classroom as a tool to assist students in learning the process skills of science. The number of tool applications for the classroom are as varied as the problem-solving tasks faced in conducting science investigations. The following examples of tool software are available for most brands of hardware:

- aids to student calculation
- aids to produce graphs for data analysis
- statistical analysis
- storage and display of laboratory data (databases and spreadsheets)
- computer collection of data (i.e., with probes)
- programming for problem solving
- laboratory simulations

Computer-based laboratory simulations can be used as a tool for laboratory investigation, allowing students to concentrate on the concepts and processes of science investigation rather than on the physical manipulation of equipment. The computer-based laboratory usually allows students to collect and analyze data at a much faster rate, resulting in inferences based upon numerous trial runs with more opportunities for variable manipulation. Since laboratory equipment skills are also important, some combination of the physical laboratory and the computer-based lab will be most beneficial for students. Where computer-based laboratory simulations are an integral part of the laboratory experience, a low student-computer ratio is essential to ensure that each student participates in the inquiry process.

# Teacher Tool Applications

Regardless of the content area, teachers are finding the computer an effective tool for the reduction of paperwork and a means to increase opportunities for effective classroom management. Teachers can use standard and specialized databases for inventory control and other classroom data storage tasks. Gradebook, attendance, and electronic scoring systems increase the teacher's ability to generate required evaluation reports. Word processing applications and capabilities to produce graphics can assist in the production of student instructional and evaluation materials. By using the computer as a tool for classroom management, the teacher can also model appropriate attitudes toward technology.

Computer technology can be a powerful tool for science instruction. The technology should be an integral part of the science curriculum and should facilitate good instructional processes rather than divert students by focusing their attention on the computer itself. The district curriculum should not be dictated by the available software, rather the courseware and tool applications should be selected to support the district curriculum.

# Evaluating Students in Science

In the current method of teaching science, students participate in activities and experiments to acquire concepts rather than memorize a list of facts presented by the teacher or textbook. Chapter 75 requires students in kindergarten through Grade 6 to spend a balance of their science instructional time between science activities and content; secondary students in Grade 7 through 12 are required to participate in laboratory-oriented instruction. While an inquiry method is desirable for teaching science skills and concepts, it poses questions concerning evaluation of the learner.

To assess all types of science outcomes, a variety of evaluation techniques should be used. The traditional method of evaluation is paper/pencil testing. Such tests include teacher-constructed tests, textbook-supplied tests, and purchased standardized tests. Most of the test items on paper/pencil tests assess content knowledge, although teachers could write items to test skills.

For students with language or learning difficulties, paper/pencil tests may be offered in a different form. The test may be given orally with oral or written responses as appropriate.

Evaluation of students' classroom activities and laboratory experiences is equally as important as evaluation of content knowledge. Students' abilities to make observations, recognize problems, formulate and test hypotheses, and gather and interpret data are competencies taught through science activities; they should be assessed accordingly. In grading experiments and laboratory activities, one method is to grade the conclusions formulated by the student. If a student identifies the components of an unknown solution, a numerical score could be given for the number of correct components. If a student builds an electric motor or circuit that functions correctly, then credit could be given. A grade could be assigned to a laboratory notebook indicating the quality of the reporting procedures. Since the majority of science essential elements are best taught through activities, checklists of the essential elements may offer the teacher a basis on which to assign a letter grade. Sample checklists are presented in Appendix I: Examples of Alternative Assessment Procedures.

Students in all grades are encouraged to conduct projects of their own according to individual interests. If these projects meet the objectives of the grade or course, then written reports, oral presentations, and displays related to them may be assessed.

Reports, both oral and written, meet the science essential elements, "experience in oral and written communication of data in appropriate form." Therefore, students are encouraged to report orally at all grades and to report in writing as appropriate. For reports, kindergarten students graph by pasting like buttons together on a histogram. They make grids of pictures of living and nonliving things under appropriate headings. The degree of sophistication of reporting in written form increases through the grades. Displays of information for projects, reports, and experimentation may also be graded.

Students' grades should reflect performance on tests, experiments, projects, and reports. By using a variety of evaluation techniques, formal and informal, evaluation of all objectives in the science program is assured.

# Suggestions for Developing A Curriculum Guide

The purpose of a state-level framework such as this publication is to provide districts, administrators, and teachers with definitions of the essential elements, examples of effective science instruction, discussion of the philosophies and goals of the science program, and interpretations of State Board of Education rules for curriculum. Districts then are responsible for developing their own curriculum guides, based on the framework, which communicate the district's instructional plan for science to teachers, parents, administrators, and school board members.

A district guide will incorporate the philosophy of science education expressed in this framework and will include a discussion of the district's own needs, goals, and resources. The content of district-produced curriculum documents will generally address a grade-level subject in the elementary school or a course taught over a full school year or semester in secondary school. Usually, curriculum planners will subdivide guides into instructional units. The units will provide specific and detailed information about goals and objectives, content to be taught, teaching and learning strategies, activities, instructional resources, and evaluation and assessment procedures.

In developing a curriculum guide, district planners should:

- **formulate goals and objectives**
  The science essential elements and subelements outline minimum skills and content students are to acquire. District planners are encouraged to expand and define the essential elements and subelements into a hierarchy of skill and content objectives. They should construct instructional objectives to communicate to students and teacher the concept or skill students are to learn, the conditions under which the learning is to occur, and the criterion of acceptable performance.

- **select and organize skills and content**
  The science subelements provide a basis of content for each grade and course. However, the content indicated in the subelements is minimum. For an instructionally sound course, content must be expanded. Science curriculum guides should help teachers make appropriate content decisions based upon the subelements and the goals and needs of the district. There is no one correct way to organize the skills and content in a science curriculum guide. However, one effective way is to organize the guides according to a sequence of concepts supported by a hierarchy of appropriate skill and content objectives and keyed to the essential elements. This method of organization provides guidance to the teacher in sequencing an instructionally sound course.

- **identify and plan for the development of science skills**
  The science essential elements outline the skills students are to develop in K-Grade 12. In curriculum guides, curriculum planners should give considerable attention to designing activities that provide opportunities for students to develop and practice the skills outlined in the required essential elements and in others identified by the district.

- **plan for teaching activities**
  The science curriculum guide must provide a variety of teaching activities, including reteaching and enrichment, for each instructional objective. A variety of activities provides valuable information to the teacher and reduces planning time and paper work.

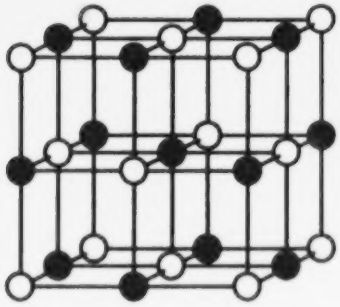
- **determine evaluation procedures and techniques**
  Evaluation of student performance is a crucial component of effective teaching. The science curriculum guide should specify an evaluation strategy for each teaching activity. The strategy may be informal as in teacher observation of student performance or formal as in test items on a unit test. The key is that the evaluation strategy focuses the teacher on monitoring student performance of the instructional or performance objective.

- **Indentify instructional resources**
  The curriculum guide should assist teachers by providing a directory of available resources. Teachers save planning time if resources such as films, filmstrips, magazines, reference materials, and computer programs are listed for each activity in the guide.

Based on a grade-level or course curriculum guide, the teacher plans daily lessons. Lesson plans indicate in a concise manner what is to be taught and what activities are to take place. Lesson plans may also include instructional resources to be used, objectives to be accomplished, and evaluation procedures to be conducted. The teacher may reference these lesson plan components if they already appear in the district curriculum guide.

The framework, the district's curriculum guide, and the teacher's lesson plans comprise the design for instruction for every student in the class. Information is available within these resources to guide the teacher in pacing, modifying, and unifying the science essential elements, science content, and instructional strategies into successful and challenging learning experiences.

# Elementary Science



# Introduction

Within each elementary school year, school districts must provide students, kindergarten through Grade 6, with a balance of content and activities from the life, earth, and physical sciences, according to State Board of Education rules. Students gain concepts by actively experimenting with science.

A typical science lesson begins with the development of a question. The teacher can get an idea for the question from the curiosity of the students or from a previous lesson. Or the teacher may pose a question to initiate a new direction of study. Once a question is developed, students investigate by manipulating materials, cooperating with fellow students, and designing experiments. Through activities, students gain concepts and find solutions. They engage in process skills that are reflected in the essential elements for science: manipulating, observing, classifying, communicating, measuring, making inferences and predictions, relating objects and events, applying defined terms, identifying and manipulating the conditions of investigations.

Science taught as investigation preserves the natural curiosity of children, encourages peer interaction, enhances creativity as students design experiments, prepares elementary students for the transition to secondary science courses, helps students develop skills useful in other study areas, and prepares them for problem solving in later life. Within the informal, small-group activities of elementary science, young students learn to appreciate and to enjoy science and the processes used by scientists. The elementary students are stimulated by effective teaching to continue to learn science and investigate their environment.

## Elementary Science Time Allocations

Science must be taught weekly in kindergarten. In Grades 1-3, within each semester, the equivalent of at least 100 minutes per week shall be devoted to teaching science. In Grades 4-6, within each six weeks, the equivalent of 225 minutes per week must be devoted to teaching science. By allowing blocks of time, State Board rules provide for flexibility in schedules for assemblies, field trips, guest speakers, and other special events. Teachers may alternate science units with social studies units, they may teach science and social studies daily, and they may integrate science and social studies units.

Teaching will be more effective if essential elements common to several content areas are reinforced throughout the day. For example, Grade 4 provides students opportunities to "use charts and graphs" in mathematics, "collect information by measuring objects and recording data on graphs" in science, "interpret visuals (pictures, charts, graphs, tables)" in social studies, and "use graphic sources for information: simple maps, globes, pictures, diagrams, bar graphs" in reading. An interdisciplinary approach provides reinforcement and enrichment of target essential elements.

## Grade 6 in the Middle School

Students in Grade 6 in the middle school must have one unit of science. A unit at Grade 6 constitutes a minimum of 45 minutes of academically engaged time per day per subject during a 175-day school year.

Grade 6 science stimulates students' curiosity in an atmosphere that encourages them to generate questions concerning their environment and how their world works. The majority of the inquiries can and should be answered through laboratory and field investigations. These activities heighten the students' interest and promote their efforts in related areas such as English language arts, mathematics, and social studies.

Science in Grade 6 includes topics from the life, earth, and physical sciences. Instruction should be structured and sequenced to develop the concepts, skills, and thought processes that will be useful to the students today and in the future. The depth of instruction should be carefully tailored to fit the interests, backgrounds, physical abilities, maturity, and educational needs of the students. Each student should achieve success.

## Teacher Certification and Qualifications

Teachers of elementary science must be elementary certified by the State of Texas. A specialization in science is not required. Administrators should consider departmentalization on campuses where teachers with science specialization are available.

Quality instruction in science is dependent upon the teacher's:

- enthusiasm to encourage the natural curiosity of students
- creativity in setting up experiments in terms of materials and conditions
- generosity in accepting students' suggestions for design of experiments and students' conclusions
- tolerance of the students' enthusiasm

## The Elementary Science Classroom

Campus administrators should consider establishing an elementary science laboratory center. In this room, science materials, equipment, and resources would be centrally located. Facilities would include cabinets for display of students' work and collections, aquaria, terraria, sinks with running water, and heat sources. If plumbing is a limiting factor, containers can be provided for water and waste water. Electric hot plates are sufficient for the heat source. Flat-topped tables or desks allow the students space for setting up the materials and encourage small group interaction.

A regular classroom which is bright and spacious can also be appropriate for science instruction. The room should be full of examples from the life, earth, and physical sciences.

Whether science is taught by a regular teacher or a science specialist, in a science room or a regular classroom, the essential elements will identify equipment and materials minimums per grade. Hand magnifiers, scales and balances, thermometers, simple machines, magnets, magnetic compasses, microscopes, and other items must be provided at the appropriate grades. (See Appendix II: Basic Materials and Equipment Lists.)

## Classroom Management

Students working in small groups call for management strategies different from those for students working independently at their desks. The same is true for students gathering data on the school campus and for students working within the confines of the classroom. Teachers can avoid confusion and promote cooperation by carefully planning and setting up activities and by assigning tasks.

In planning, the teacher ensures that everything is available for the experience prior to the students' encounter with the lesson. Materials are provided in adequate quantities. They can be sorted and contained within shoe boxes or on cardboard trays. At the time of the experiment, one container is disseminated per group rather than disseminating individual items necessary for the experiment. Collecting materials at the end of the lesson is expedited, since the teacher can quickly inventory the contents of the box or tray.

Most activities are arranged according to a prelaboratory, laboratory, and a postlaboratory format. During the prelaboratory phase, the teacher and the students design an experiment through which they will best find solutions to the question being investigated. Safety procedures are discussed. Group membership and each individual's responsibilities to the group are assigned. During the laboratory phase, the students discover possible solutions to the question. They use the science processes to reach conclusions. During the postlaboratory phase, the small groups share their findings, and the entire class comes to closure.

Some science experiments may not come to a desired conclusion. Rather than consider these experiments failures, teachers may let them be opportunities for students to suggest what may have happened to alter the expected results.

## Science, Kindergarten

| Essential elements | Subelements |
|---|---|
| Science, kindergarten, shall have a balance of content and activities from the life, earth, and physical sciences and shall include the following essential elements: | The student shall be provided opportunities to: |
| (1) Manipulative laboratory skills | (A) use comparators: color, texture, taste, odor, size, shape, direction, motion, heat/cold, sink/float, sound<br>(B) practice safety |
| (2) The use of skills in acquiring data through the senses | (A) observe color, texture, size, shape of objects<br>(B) observe objects in the environment<br>(C) observe events and changes in the environment |
| (3) The use of classification skills in ordering and sequencing data | (A) classify objects by comparing similarities and differences<br>(B) classify objects from the environment as being living or nonliving<br>(C) arrange events in sequential order |
| (4) Experience in oral and written communication of data in appropriate form | (A) describe objects from the environment<br>(B) describe external features of organisms |

## Science, Grade 1

| Essential elements | Subelements |
|---|---|
| Science, Grade 1, shall have a balance of content and activities from the life, earth, and physical sciences and shall include the following essential elements: | The student shall be provided opportunities to: |
| (1) Manipulative laboratory skills | (A) use hand magnifiers<br>(B) use comparators: length, area, shape, height, size, texture, color<br>(C) practice safety |
| (2) The use of skills in acquiring data through the senses | (A) observe properties of selected plants and animals<br>(B) observe the differences and similarities in the physical world<br>(C) identify a variety of simple machines |
| (3) The use of classification skills in ordering and sequencing data | (A) classify objects by comparing similarities and differences<br>(B) classify objects from the environment |
| (4) Experience in oral and written communication of data in appropriate form | (A) describe objects and events (sunrise, sunset, flood) from the environment<br>(B) describe apparent changes in size of objects at various distances<br>(C) describe the human use of plants and animals<br>(D) name the senses |
| (5) Experience in concepts and skills of measurement using relationships to standards | measure objects from the environment |

## Science, Grade 2

| Essential elements | Subelements |
|---|---|
| Science, Grade 2, shall have a balance of content and activities from the life, earth, and physical sciences and shall include the following essential elements: | The student shall be provided opportunities to: |
| (1) Manipulative laboratory skills | (A) use scales and balances<br>(B) use thermometers<br>(C) use comparators: mass, volume, symmetry, temperature, texture, size, shape<br>(D) use rulers<br>(E) practice safety |
| (2) The use of skills in acquiring data through the senses | (A) observe patterns in properties of selected plants, animals, and objects<br>(B) observe that time is based on counting regular events<br>(C) observe models from the life, earth, physical sciences |
| (3) The use of classification skills in ordering and sequencing data | (A) classify objects or selected plants and animals by comparing similarities and differences<br>(B) sequence objects and events |
| (4) Experience in oral and written communication of data in appropriate form | (A) name objects from a description of their properties<br>(B) describe what is shown in an illustration<br>(C) interpret the arrangement of data |
| (5) Experience in concepts and skills of measurement using relationships to standards | record measurement of objects |
| (6) The use of skills in drawing logical inferences, predicting outcomes, and forming generalized statements | (A) predict the outcome of an action<br>(B) predict the uses organisms make of their environment |

## Science, Grade 3

| Essential elements | Subelements |
|---|---|
| Science, Grade 3, shall have a balance of content and activities from the life, earth, and physical sciences and shall include the following essential elements: | The student shall be provided opportunities to: |
| (1) Manipulative laboratory skills | (A) use simple machines<br>(B) use comparators: time, distance, speed<br>(C) practice safety |
| (2) The use of skills in acquiring data through the senses | (A) observe patterns of growth in selected organisms<br>(B) observe that life occurs in cycles<br>(C) observe physical structures |
| (3) The use of classification skills in ordering and sequencing data | (A) classify objects or events by comparing similarities and differences in their properties<br>(B) classify simple machines<br>(C) classify natural resources |
| (4) Experience in oral and written communication of data in appropriate form | (A) describe changes that occur in the environment<br>(B) describe the event illustrated in a picture or diagram<br>(C) describe three states of matter (solid, liquid, gas)<br>(D) obtain science information from varied resources |
| (5) Experience in concepts and skills of measurement using relationships to standards | (A) record measurement of objects<br>(B) map and measure the locations of objects |
| (6) The use of skills in drawing logical inferences, predicting outcomes, and forming generalized statements | predict the outcome of an action |

## Science, Grade 4

| Essential elements | Subelements |
|---|---|
| Science, Grade 4, shall have a balance of content and activities from the life, earth, and physical sciences and shall include the following essential elements: | The student shall be provided opportunities to: |
| (1) Manipulative laboratory skills | (A) use magnets<br>(B) construct an electromagnet<br>(C) use metric balances<br>(D) use magnetic compasses<br>(E) use comparators: mass, volume<br>(F) practice safety |
| (2) The use of skills in acquiring data through the senses | (A) observe phenomena and apply knowledge of facts and concepts<br>(B) observe that all living organisms depend on plants (food chains, food webs) |
| (3) The use of classification skills in ordering and sequencing data | classify organisms, actions, or events according to similarities and differences |
| (4) Experience in oral and written communication of data in appropriate form | (A) describe changes in objects and events over a period of time (position, rate of speed)<br>(B) describe the changes that occur in weather and their effects<br>(C) describe information obtained from charts, graphs, histograms<br>(D) describe how plants and animals protect themselves |
| (5) Experience in concepts and skills of measurement using relationships to standards | (A) collect information by measuring objects and recording data on graphs<br>(B) measure the growth of plants and animals |
| (6) The use of skills in drawing logical inferences, predicting outcomes, and forming generalized statements | predict an outcome from a trend in data (weather forecasting, position of an object versus time and rate of speed) |
| (7) Experience in skills in relating objects and events to other objects and events | (A) compare objects according to motion, mass, volume<br>(B) relate knowledge and skills of science to careers |
| (8) Experience in applying defined terms based on observations | apply knowledge of facts and concepts in explaining observations in experimental and controlled situations |

## Science, Grade 5

| Essential elements | Subelements |
|---|---|
| Science, Grade 5, shall have a balance of content and activities from the life, earth, and physical sciences and shall include the following essential elements: | The student shall be provided opportunities to: |
| (1) Manipulative laboratory skills | (A) construct models<br>(B) use a microscope<br>(C) practice safety |
| (2) The use of skills in acquiring data through the senses | (A) observe phenomena of natural cycles<br>(B) observe the results of phenomena associated with electricity (charges, magnetic poles)<br>(C) observe the effects of phenomena associated with light or sound |
| (3) The use of classification skills in ordering and sequencing data | (A) classify objects, actions, or events according to similarities and differences<br>(B) classify materials as being metallic or nonmetallic<br>(C) classify human body systems and their functions |
| (4) Experience in oral and written communication of data in appropriate form | (A) describe changes in objects and events (rock cycles, life cycles, phases of the moon)<br>(B) interpret meaningful arrangements of data |
| (5) Experience in concepts and skills of measurement using relationships to standards | (A) collect information by measuring objects and recording data on graphs and tables<br>(B) measure weather conditions (temperature, wind direction and speed, humidity) |
| (6) The use of skills in drawing logical inferences, predicting outcomes, and forming generalized statements | (A) predict an outcome from a trend in data<br>(B) predict cause-and-effect relationships |
| (7) Experience in skills in relating objects and events to other objects and events | (A) compare objects according to motion, volume, mass, and speed<br>(B) relate knowledge and skills of science to careers<br>(C) compare various ecosystems |

## Science, Grade 5, *continued*

| Essential elements | Subelements |
|---|---|
| Science, Grade 5, shall have a balance of content and activities from the life, earth, and physical sciences and shall include the following essential elements: | The student shall be provided opportunities to: |
| (8) Experience in applying defined terms based on observations | state the differences between objects and events using an operational definition |
| (9) Experience in identifying and manipulating the conditions of investigations | identify the variables being manipulated and the variables responding in an investigation |

## Science, Grade 6

| Essential elements | Subelements |
|---|---|
| Science, Grade 6, shall have a balance of content and activities from the life, earth, and physical sciences and shall include the following essential elements: | The student shall be provided opportunities to: |
| (1) Manipulative laboratory skills | (A) construct an electrical device (telegraph, electric motor)<br>(B) use a microscope<br>(C) use acid-base indicators<br>(D) practice safety |
| (2) The use of skills in acquiring data through the senses | (A) observe phenomena and apply knowledge of facts, theories, laws, structures, and concepts<br>(B) observe the cellular composition of organisms<br>(C) observe that energy can be changed from one form to another |
| (3) The use of classification skills in ordering and sequencing data | (A) classify organisms, objects, actions, or events according to similarities and differences<br>(B) classify variables as being constant, manipulated, or responding<br>(C) classify substances as acid or base |
| (4) Experience in oral and written communication of data in appropriate form | (A) describe the meaning of graphs and discuss factors that govern the rates of change<br>(B) describe animal behaviors<br>(C) describe the patterns of data<br>(D) describe technological advances (computers, lasers, space and ocean exploration, communication systems)<br>(E) describe the sequence of events in an investigation<br>(F) describe consumer information from tables, labels, and advertisements |
| (5) Experience in concepts and skills of measurement using relationships to standards | collect information by measuring and recording data on graphs, diagrams, and other visual materials |

## Science, Grade 6, *continued*

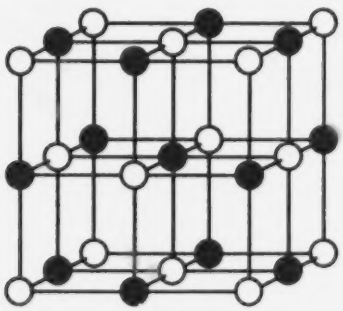
| Essential elements | Subelements |
|---|---|
| Science, Grade 6, shall have a balance of content and activities from the life, earth, and physical sciences and shall include the following essential elements: | The student shall be provided opportunities to: |
| (6) The use of skills in drawing logical inferences, predicting outcomes, and forming generalized statements | (A) predict an outcome from a trend in data (extrapolation, interpolation)<br>(B) predict and compare the amount of energy used in various electrical devices<br>(C) deduce from given information the cause-and-effect relationships |
| (7) Experience in skills relating objects and events to other objects and events | (A) compare factors that affect growth rate<br>(B) compare the effects of the use of alternate energy sources<br>(C) relate knowledge and skills of science to careers |
| (8) Experience in applying defined terms based on observation | state the differences between organisms, objects, and events using an operational definition |
| (9) Experience in identifying and manipulating the conditions of investigations | (A) identify the variables held constant, those variables being manipulated, and the variables responding in an investigation<br>(B) design and conduct an investigation |

# SCIENCE

→ indicates continuation and progression

| **Every elementary school shall offer a science program that has a balance of content and activities and that includes the following essential elements** | **The student shall be provided opportunities to:** | | | | | | |
|---|---|---|---|---|---|---|---|
| | **K** | **1** | **2** | **3** | **4** | **5** | **6** |
| Manipulative laboratory skills | Use comparators: color, texture, taste, odor, size, shape, direction, motion, heat/cold, sink/float, sound<br>Practice safety → | Use hand magnifiers<br>Use comparators: length, area, shape, height, size, texture, color | Use scales and balances<br>Use thermometers<br>Use comparators: mass, volume, symmetry, temperature, texture, size, shape<br>Use rulers | Use simple machines<br>Use comparators: time, distance, speed | Use magnets<br>Construct an electromagnet<br>Use metric balances<br>Use magnetic compasses<br>Use comparators: mass, volume | Construct models<br>Use a microscope | Construct an electrical devise (telegraph, electric motor)<br>Use a microscope<br>Use acid-base indicators |
| The use of skills in acquiring data through the senses | Observe color, texture, size, shape of objects<br>Observe objects in the environment<br>Observe events and changes in the environment | Observe properties of selected plants and animals<br>Observe the differences and similarities in the physical world<br>Identify a variety of simple machines | Observe patterns in properties of selected plants, animals, and objects<br>Observe that time is based on counting regular events<br>Observe models from the life, earth, and physical sciences | Observe patterns of growth in selected organisms<br>Observe that life occurs in cycles<br>Observe physical structures | Observe phenomena and apply knowledge of facts and concepts<br>Observe that all living organisms depend on plants (food chains, food webs) | Observe phenomena of natural cycles<br>Observe the results of phenomena associated with electricity (charges, magnetic poles)<br>Observe the effects of phenomena associated with light or sound | Observe phenomena and apply knowledge of facts, theories, laws, structures, and concepts<br>Observe the cellular composition of organisms<br>Observe that energy can be changed from one form to another |
| The use of classification skills in ordering and sequencing data | Classify objects comparing similarities and differences<br>Classify objects from the environment as being living or nonliving<br>Arrange events in sequential order | Classify objects by comparing similarities and differences<br>Classify objects from the environment | Classify objects or selected plants and animals by comparing similarities and differences<br>Sequence objects and events | Classify objects or events by comparing similarities and differences in their properties<br>Classify simple machines<br>Classify natural resources | Classify organisms, actions, or events according to similarities and differences | Classify objects, actions, or events according to similarities and differences<br>Classify materials as being metallic or nonmetallic<br>Classify human body systems and their functions | Classify organisms, objects, actions, or events according to similarities and differences<br>Classify variables as being constant, manipulated, or responding<br>Classify substances as acid or base |
| Experience in oral and written communication of data in appropriate form | Describe objects from the environment<br>Describe external features of organisms | Describe objects and events (sunrise, sunset, flood) from the environment<br>Describe apparent changes in size of objects a various distances<br>Describe the human use of plants and animals<br>Name the senses | Name objects from a description of their properties<br>Describe what is shown in an illustration<br>Interpret the arrangement of data | Describe changes that occur in the environment<br>Describe the event illustrated in a picture or diagram<br>Describe three states of matter (solid, liquid, gas)<br>Obtain science information from varied resources | Describe changes in objects over a period of time (position, rate of speed)<br>Describe the changes that occur in weather and their effects<br>Describe information obtained from charts, graphs, histograms<br>Describe how plants and animals protect themselves | Describe changes in objects and events (rock cycles, life cycles, phases of the moon)<br>Interpret meaningful arrangements of data | Describe the meaning of graphs and discuss factors that govern the rates of change<br>Describe animal behaviors<br>Describe the patterns of data<br>Describe technological advances (computers, lasers, space and ocean exploration, communications systems)<br>Describe the sequence of events in an investigation<br>Describe consumer information from tables, labels, and advertisements |
| Experience in concepts and skills of measurement using relationships to standards | | Measure objects from the environment | Record measurement of objects → Map and measure the locations of objects | | Collect information by measuring objects and recording data on graphs<br>Measure the growth of plants and animals | Collect information by measuring and recording data on graphs and tables<br>Measure the weather conditions (temperature, wind direction and speed, humidity) | Collect information by measuring and recording data on graphs, diagrams, and other visual materials |
| The use of skills in drawing logical inferences, predicting outcomes, and forming generalized statements | | | Predict the outcome of an action<br>Predict the uses organisms make of their environment | Predict the outcome of an action | Predict an outcome from a trend in data (weather forecasting, position of an object versus time and rate of speed) | Predict an outcome from a trend in data<br>Predict cause-and-effect relationships | Predict an outcome from trends in data (extrapolation, interpolation)<br>Predict and compare the amount of energy used in various electrical devices<br>Deduce from given information the cause-and-effect relationships |
| Experience in skills in relating objects and events to other objects and events | | | | | Compare objects according to motion, mass, volume<br>Relate knowledge and skills of science to careers → | Compare objects according to motion, volume, mass, and speed<br>Compare various ecosystems | Compare factors that affect growth rate<br>Compare the effects of the use of alternate energy sources → |
| Experience in applying defined terms based on observations | | | | | Apply knowledge of facts and concepts in explaining observations in experimental and controlled situations | State the differences between objects and events using an operational definition | State the differences between organisms, objects, and events using an operational definition |
| Experience in identifying and manipulating the conditions of investigations | | | | | | Identify the variables being manipulated and the variables responding in an investigation | Identify the variables held constant, those variables being manipulated, and the variables responding in an investigation<br>Design and conduct an investigation |

# Secondary Science



# JUNIOR HIGH SCHOOL SCIENCE

## Introduction

Because students in Grades 7 and 8 represent a physical, intellectual, and social diversity not found in any other age group, science instruction at this level has several unique characteristics.

First, additional goals are required that address the physical, intellectual, and social needs of early adolescents. Junior high students are encouraged to:

- integrate previously acquired and newly learned basic skills, attitudes, and knowledge
- explore individual interests, aptitudes, and abilities in the life and earth sciences
- develop decision-making skills that guide the making of intelligent decisions with regard to future educational and vocational decisions

Second, the instructional system of the junior high science classroom should be adapted to deal efficiently with the varying intellectual and physical developments of the early adolescent. Recent studies of the traditional junior high science classroom have characterized it as a routine of lecture, recitation, discussion, and testing. Although these are valuable instructional techniques, the current emphasis in Chapter 75 is on science process skills as outlined in the essential elements. Laboratory and field work, in conjunction with traditional techniques, provide opportunities for students to acquire additional skills and knowledge in the earth and life sciences. A variety of laboratory and field investigations provides students with concrete and first-hand experiences that facilitate the mental transition from concrete to formal operations. (See Science Laboratory Instruction, p.12.)

Third, the science classroom environment should be one that facilitates development of social skills students require to participate in a complex democratic society. Small-group interactions through laboratory/field work, panel discussions, and group projects promote students' acceptance of peer ideas. Students learn to make contributions to the group and to work toward common goals.

Chapter 75 stipulates that students in Grades 7 and 8 must take one unit of life science and one unit of earth science. A unit requires a minimum of 45 minutes of academically engaged time per day per course during a 175-day school year. Science courses must be laboratory oriented (i.e., a minimum of 40 percent of the instructional time must be devoted to laboratory/field activities).

To meet the requirements for 40 percent laboratory/field instruction, campuses must provide a sufficient number of laboratories for classes of students taking the various sciences, a sufficient number of work stations for students per class, and a sufficient variety and number of consumable and nonconsumable materials and equipment per student. A minimum list of suggested materials and equipment is provided in Appendix II.

## Course Descriptions, Essential Elements, and Topics

Junior high students expand their knowledge of earth and life sciences from a framework of skills and concepts acquired in elementary school. The following course descriptions for Earth Science and Life Science are accompanied by essential elements and suggested topics. The information is minimum and does not represent the total curriculum. Suggested topics are listed in random order and may not necessarily receive equal emphasis. The topic, International Systems (SI) of Measurement, is common to all courses.

## Life Science

Life Science is a study of the nature and diversity of organisms in their environment. Important themes include the energy flow in the biosphere, the biological processes of plants and animals, and the structure, function, and maintenance of the human body.

The course emphasizes individual and/or small-group laboratory and field investigations. It focuses upon the observation of behaviors of living organisms and natural phenomena. Investigations emphasize accurate observations, collection of data, data analysis, and the safe manipulation of laboratory apparatus and materials.

Life Science also includes a three-week unit per semester of health education. The unit addresses drugs, safety, and communicable and noncommunicable diseases. If the district requires a half unit of health for every junior high student, Life Science need not include the health essential elements.

## Life Science (1 unit)

| Essential elements | Subelements |
|---|---|
| Life Science shall be a laboratory-oriented course and shall include the following essential elements: | The student shall be provided opportunities to: |
| (1) Manipulative laboratory skills | (A) demonstrate the safe use of microscopes, other biological equipment, and chemicals in life science investigations<br>(B) prepare wet- and dry-mount slides |
| (2) The use of skills in acquiring data through the senses | observe selected plants and animals and their growth patterns |
| (3) The use of classification skills in ordering and sequencing data | classify plants and animals according to similarities, differences, and uses |
| (4) Experience in oral and written communication of data in appropriate form | (A) describe the essential life activities carried on by living cells<br>(B) describe ecological relationships in the environment |
| (5) Experience in concepts and skills of measurement using relationships to standards | (A) measure life processes<br>(B) plot data on graphs and other displays |
| (6) The use of skills in drawing logical inferences, predicting outcomes, and forming generalized statements | (A) formulate an experimental design to test an hypothesis in life science<br>(B) predict the outcome of life processes |
| (7) Experience in skills in relating objects and events to other objects and events | (A) compare organism adaptations to environmental changes<br>(B) compare the rates of life processes |

## Life Science, *continued*

| Essential elements | Subelements |
|---|---|
| Life Science shall be a laboratory-oriented course and shall include the following essential elements: | The student shall be provided opportunities to: |
| (8) Experience in applying defined terms based on observations | clarify operational definitions used in explaining life processes |
| (9) Experience in identifying and manipulating the conditions of investigations | identify the variables remaining constant, the variables being manipulated, and the variables responding in a life science investigation |
| (10) Application of science in daily life | (A) analyze the economic importance of selected plants and animals<br>(B) evaluate the applications and career implications of life science principles and the findings of research |
| (11) Health concepts and skills. (A three-week unit of health education including these essential elements shall be taught each semester within this life science course.) | (A) determine alternate courses of action when one is being pressured concerning use of alcohol, tobacco, marijuana, and other drugs<br>(B) investigate the range of effects on personal health and safety from the use of alcohol, tobacco, marijuana, and other drugs<br>(C) discriminate between responsible and irresponsible choices that affect personal health<br>(D) identify principles of rescue, transfer, and aid to persons choking or not breathing<br>(E) investigate the causes, symptoms, prevention, and treatment of communicable and noncommunicable diseases, including sexually transmitted diseases<br>(F) demonstrate basic knowledge of laws and describe governmental regulations related to production, distribution, and use of alcohol, tobacco, marijuana, and other drugs |

## Suggested Topics for Life Science

**Living Organisms**
- characteristics of living organisms
- organization of cells, tissues, organs, and systems
- classification of living organisms

**Cell Structure and Function**
- parts of cells
- cells and energy
- cellular regulation and reproduction

**Protista—Structure, Function, and Economic Importance**

**Monera—Structure, Function, and Economic Importance**

**Fungi—Structure, Function, and Economic Importance**

**Plants—Structure, Function, and Economic Importance**
- fungi
- mosses
- ferns
- seed plants

**Animals—Structure, Function, Economic Importance, and Behaviors**
- invertebrates
- vertebrates

**Viruses**

**Human Body Systems**
- skeletal
- muscular
- integumentary
- digestion
- circulation
- respiration
- excretion
- nervous
- endocrine
- reproductive

**Genetics and Heredity**
- genes and chromosomes
- human heredity
- applications of genetics
- scientific theories of evolution

**Ecosystems and the Environment**
- cycles in the ecosystem
- successions
- biomes
- populations

**People and the Environment**
- conservation of natural resources
- pollution and the ecosystem
- endangered organisms

**Scientists and Their Contributions**

**Careers in Science**

**Health Concepts and Skills**

- effects of drugs
- personal health choices
- diseases
- rescue techniques

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## Earth Science

Earth Science presents a study of fundamental concepts in geology, oceanography, meteorology, and astronomy. As a laboratory-oriented course, Earth Science is designed to promote an understanding of basic concepts, models, and theories through investigations and experimentation.

Students acquire data using their senses and instrumentation. Observations are made of planetary phenomena, structures of the earth's crust, bodies of water, and weather patterns. The investigations performed emphasize accurate observations, collection of data, data analysis, and the safe manipulation of laboratory apparatus and materials in the field and in the laboratory.

## Earth Science (1 unit)

| **Essential elements**<br>Earth Science shall be a laboratory-oriented course and shall include the following essential elements: | **Subelements**<br>The student shall be provided opportunities to: |
|---|---|
| (1) Manipulative laboratory skills | (A) demonstrate the safe use of earth science equipment and chemicals<br>(B) prepare display collections of earth materials<br>(C) demonstrate skills using laboratory instruments |
| (2) The use of skills in acquiring data through the senses | (A) observe earth materials and structures, changes in the weather, astronomical objects<br>(B) examine geological, star, and weather maps |
| (3) The use of classification skills in ordering and sequencing data | classify objects or events according to similarities and differences |
| (4) Experience in oral and written communication of data in appropriate form | (A) describe renewable and nonrenewable resources<br>(B) describe the effects of earth science processes<br>(C) draw a topographic map using points of measured elevation |
| (5) Experience in concepts and skills of measurement using relationships to standards | (A) measure earth science properties<br>(B) plot data on graphs, maps, and other displays |
| (6) The use of skills in drawing logical inferences, predicting outcomes, and forming generalized statements | (A) predict the outcome of an earth science activity from trends in experimental data using interpolation or extrapolation<br>(B) formulate an earth science hypothesis from experimental data |

## Earth Science, *continued*

| Essential elements | Subelements |
|---|---|
| Earth Science shall be a laboratory-oriented course and shall include the following essential elements: | The student shall be provided opportunities to: |
| (7) Experience in skills in relating objects and events to other objects and events | (A) compare geologic time in relation to life forms and events<br>(B) analyze scale models of stratified structures<br>(C) compare and contrast types of weather patterns<br>(D) contrast human activities that affect the natural environment |
| (8) The use of defined terms based on experience and observation | clarify operational definitions used to explain earth processes |
| (9) Experience in identifying and managing the conditions of investigations | (A) identify the variables remaining constant, the variables being manipulated, and the variables responding in an earth science investigation<br>(B) manage an experimental apparatus to test an earth science hypothesis |
| (10) Application of science in daily life | evaluate the applications and career implications of earth science principles and the findings of research |

### Suggested Topics for Earth Science

**Geology**

Composition of Matter
- classification
- minerals
- crystal formation
- mineral formation

Rocks
- rock cycle
- classification

Structure of the Earth

Geologic Processes: Vulcanism, Earthquakes, Mountain Building, Weathering

Plate Tectonics

Hydrology
- hydrologic cycle
- classification and characteristics of water sources (lakes, ponds, reservoirs, streams, aquifers)
- porosity and permeability of soils and rocks

Mapping
- topography
- map interpretation

Earth's History
- formation of strata
- fossil formation and interpretation
- geologic time
- scientific theories of evolution

Earth's Environment
- renewable and nonrenewable resources
- conservation of resources
- pollution (air, water, soil)

**Oceanography**
- Chemical Make-up of Oceans' Waters
- Ocean Phenomena (waves, tides, currents, turbidity)
- Marine Environments and Their Physical Characteristics
- Geography of the Ocean

**Meteorology**
- Structure and Physical Characteristics of the Atmosphere
- Relationship Among Radiant Energy, the Atmosphere, and the Earth's Surface
- Atmospheric Pressure
- Seasons and Climate
- Scientific Weather Prediction

**Astronomy**
- Scientific Theories of the Origin of the Universe
- Planet Earth
  - movement
  - relationship to sun and moon
- Exploration of Space
  - development of space flight, technology, and future directives

Solar System
- the sun: physical and chemical characteristics
- the planets: physical characteristics, motions, orbitals, configurations
- comets, meteors, and asteroids

Stars and Galaxies
- stellar distances, color, and brightness
- nebulae and star clusters
- pulsars, quasars, and black holes

# HIGH SCHOOL SCIENCE

## Introduction

In the senior high science program, students explore a variety of science disciplines and increase their proficiency in the science skills outlined by the essential elements. Each secondary science course emphasizes the same 10 essential elements taught at the elementary and junior high levels.

Subelements reflect the increasing abstractness of the subject matter as the courses become more advanced. The essential elements and their subelements are minimum standards. They are not meant to be inclusive in content or skills. Thus, district administrators have the flexibility to design courses that incorporate the needs and interests of the students, needs of local resources of the community, and local curriculum goals and objectives. Chapter 75 lists 18 state-approved courses.

Introductory Biology (one unit)
Biology I (one unit)
Biology II (one unit)
Anatomy and Physiology (one-half to one unit)
Environmental Science (one-half to one unit)
Marine Science (one-half to one unit)
Introductory Physical Science (one unit)
Physical Science (one unit)
Chemistry I (one unit)
Chemistry II (one unit)
Physics I (one unit)
Physics II (one unit)
Aerospace-Aviation Education I (one-half to one unit)
Aerospace-Aviation Education II (one-half to one unit)
Geology (one-half to one unit)
Meteorology (one-half to one unit)
Astronomy (one-half to one unit)
Laboratory Management (one-half to one unit)

School districts must offer Introductory Biology, Biology I, Chemistry I, Physics I, and Physical Science every year or every other year. Other state-approved courses may be offered depending upon student interest, enrollment, and local resources. All science courses in Grades 9-12 are laboratory oriented (i.e., a minimum of 40 percent of the instructional time must be devoted to laboratory or field activites exclusive of teacher demonstration).

Two courses, Introductory Physical Science and Introductory Biology, are designed for a special population of students whose needs are not met by the more academic, regular courses. In these courses, the essential elements respond to the individual's need for science in everyday life by emphasizing manipulative skills, rational thinking skills, science knowledge, and applications of science. Each of these essential elements contains subelements that respond to living with self and others, career, consumer, and leisure choices. Criteria for students entering Introductory Biology and Introductory Physical Science should be determined by the school district.

## Recommended Prerequisites

Prerequisites are recommended for advanced science courses such as Biology II, Chemistry II, Physics II, and Laboratory Management because of their advanced and interdisciplinary nature. School districts

have the option of setting the number of prerequisities required for entry into these and other state-approved courses. Prerequisites are recommended as follows:

| COURSE | PREREQUISITE |
|---|---|
| **Biology II** | one unit of Biology I; one unit of Chemistry I (may be taken concurrently) |
| **Physiology and Anatomy** | one unit of Biology I |
| **Chemistry II** | one unit of Chemistry I; one unit of Physics I (may be taken concurrently) |
| **Physics II** | one unit of Physics I; one unit of Chemistry I (may be taken concurrently) |
| **Laboratory Management** | The student should have one unit of credit in the science course in which he or she will be trained to serve as a laboratory assistant. |

## Graduation Requirements

### High School Program

During Grades 9-12, all students must complete two units of science selected from the list of state-approved science courses. To ensure students are given a well-balanced science exposure, the district should encourage students to gain their two units of science credit (9-12) from among the life science, physical science, and earth science courses. Specifically, a district should not schedule students to take Introductory Biology and Biology I for their science credit. Rather, Introductory Biology and Introductory Physical Science or Chemistry I provides a better balance of science for students.

A unit of credit is one 55-minute period per day for the 175-day school year. Districts may award credit semester-by-semester for a full-year (one-unit) course.

### Advanced High School Program

Students who wish to complete an advanced high school program must earn three units of science selected from the following state-approved courses:

Biology I
Biology II
Physiology and Anatomy
Environmental Science
Marine Science
Physical Science
Chemistry I
Chemistry II
Physics I
Physics II
Geology
Meteorology
Astronomy
Laboratory Management

## Variations of the Science Program

### Honors Courses

Students may select advanced high school honors courses from the above list. The essential elements and subject content of the courses must be expanded and enriched for students meeting the entry requirements specified by the district. Instructional strategies should facilitate the development of higher level critical thinking skills and provide opportunities for independent and guided research. School districts must submit descriptions of honors courses to the Commissioner of Education for consideration of approval at least six months prior to proposed implementation. Expectations for students should be high. Cooperation among students, teachers, parents, and community members should be fostered.

### Advanced Placement Courses

The advanced placement program in Biology II, Chemistry II, and Physics II is an effort to offer college-level courses to secondary students. It is a national program regulated by The College Board. General content is specified along with certain laboratory experiences. Advanced placement courses must satisfy the 40 percent rule for laboratory investigations. A passing score on the advanced placement examination prepared by the Educational Testing Service may result in the awarding of college credit.

# Course Descriptions, Essential Elements, and Topics

Following are course descriptions, essential elements, and suggested topics for each state-approved high school science course. The information is minimum and does not represent the total curriculum. Suggested topics are listed in random and need not necessarily receive equal emphasis. The topic, International System (SI) of Measurement, is common to all courses.

## Introductory Biology

Introductory Biology presents a study of organisms and their relationship to the environment for the low aptitude and/or low interest student. The course presents the fundamental concepts of biology and their uses in everyday life. Laboratory activities are especially important because they provide concrete representations of abstract concepts and reinforce learning. Teachers should choose and direct activities in a manner to assure students' success in understanding and using the concept presented. Emphasis is placed on consumer skills, career opportunities, environmental impact of personal actions, and societal issues.

## Introductory Biology (1 unit)

| Essential elements | Subelements |
|---|---|
| Introductory Biology shall be a laboratory-oriented course and shall include the following essential elements: | The student shall be provided opportunities to: |
| (1) Manipulative skills | (A) use laboratory/field materials and equipment (plant and animal investigation and management)<br>(B) utilize materials and devices in a manner that maximizes safety and conservation (pest control, waste disposal) |
| (2) Rational thinking skills | (A) organize thought processes which will contribute to personal well-being (medical decisions, nutrition)<br>(B) evaluate endorsements, advertisements, products, and services (foods, medicine, apparel)<br>(C) make logical decisions concerning the different biological characteristics of humans and their needs (air and water quality, genetics, physical impairments) |

## Introductory Biology, *continued*

| Essential elements | Subelements |
|---|---|
| Introductory Biology shall be a laboratory-oriented course and shall include the following essential elements: | The student shall be provided opportunities to: |
| (3) Science knowledge | (A) acquire biological information to maintain the individual's well-being (human body systems; diseases: prevention, symptoms, and treatment; plant and animal systems: vascular, life cycles)<br>(B) acquire biological principles and concepts that apply to a consumer (food: acquisition, preparation, and preservation; cosmetics; ecology)<br>(C) acquire scientific information related to technology and society from historical and contemporary points of view (cell theory, photosynthesis, vaccines, environmental quality) |
| (4) Applications of sciences | (A) consider the consequences of personal actions (pollution, health practices, products and services)<br>(B) evaluate biology-related career choices as being of value to self and society (financial and service goals, opportunities for career advancements, working conditions)<br>(C) develop a sense of satisfaction in pursuing personal interests (human body needs: exercise, relaxation; plant and animal care)<br>(D) apply biological knowledge in a manner that results in optimum benefit for society (research, participation in public affairs, public service) |

## Suggested Topics for Introductory Biology

**Living Organisms**

comparison of living versus nonliving organisms
classification of living organisms

**Plants**

structure and function
diseases
people's use and misuse of plants
career opportunities
avocational opportunities

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**Animals**
- structure and function
- diseases
- people's use and misuse of animals
- career opportunities
- avocational opportunities

**Consumer Skills**
- food and nutrition
- selection and preservation of foods
- consumer choices (foods, medicine, products)
- consumer protection

**Structure and Functional Characteristics of Body Systems** (as they relate to individual well-being)

**Heredity and the Environment**
- principles of genetics
- genes and chromosomes
- genetic disorders
- application of genetics

**Human Diseases: Prevention, Symptoms, and Treatments**
- communicable diseases
- noncommunicable diseases

**Environment**
- safety
- endangered organisms
- people's disturbance of the ecosystem
- management of natural resources

**Applications of Biological Principles and Concepts to Everyday Life**
- use of microbes in the manufacturing of medicine
- use of selected controls of harmful insects

## Biology I

Biology I is the study of the structure, growth, and function of the life systems of selected organisms. This study will encompass historical contributions to biological concepts; energy production, transfer, and use in living systems; and the interrelatedness of organisms with each other and with their environments.

Students acquire data using their senses and instrumentation. Observations are made of living organisms in the environment, prepared specimens, various ecosystems, and inherited traits. Student investigations emphasize accurate observations, collection of data, data analysis, and the safe manipulation of laboratory apparatus and materials in the field and the laboratory.

## Biology I (1 unit)

| Essential elements | Subelements |
|---|---|
| Biology I shall be a laboratory-oriented course and shall include the following essential elements: | The student shall be provided opportunities to: |
| (1) Manipulative laboratory skills | (A) demonstrate the safe use of biological equipment and selected chemicals<br>(B) prepare display collections of biological specimens |
| (2) The use of skills in acquiring data through the senses | (A) observe plants, animals, and protists in their environment<br>(B) examine biological specimens<br>(C) recognize patterns in nature |
| (3) The use of classification skills in ordering and sequencing data | classify plants, animals, protists, and viruses according to similarities and differences |
| (4) Experience in oral and written communication of data in appropriate form | (A) describe biological processes and interactions<br>(B) explain meaningful arrangements of biological information |
| (5) Experience in concepts and skills of measurement using relationships to standards | (A) measure biological quantities<br>(B) plot data on graphs and other displays |
| (6) The use of skills in drawing logical inferences, predicting outcomes, and forming generalized statements | (A) predict the outcome of manipulating a variable<br>(B) deduce a biological hypothesis from experimental data |

## Biology I, *continued*

| Essential elements | Subelements |
|---|---|
| Biology I shall be a laboratory-oriented course and shall include the following essential elements: | The student shall be provided opportunities to: |
| (7) Experience in skills in relating objects and events to other objects and events | (A) analyze scale models of DNA and RNA<br>(B) compare and contrast modes of defense used by organisms<br>(C) compare adaptations of organisms to environmental changes<br>(D) contrast human activities that affect the natural environment |
| (8) Experience in applying defined terms based on observations | clarify operational definitions used in explaining digestion, respiration, circulation, reproduction of organisms, and skeletal, nervous, and endocrine systems |
| (9) Experience in identifying and manipulating the conditions of investigations | (A) identify the variables remaining constant, the variables being manipulated, and the variables responding in an investigation in biology<br>(B) choose an experimental design to test a biological hypothesis |
| (10) Application of science in daily life | (A) analyze the economic importance of microbes, plants, and animals<br>(B) evaluate consumer skills as they affect human well-being<br>(C) evaluate the applications and career implications of biology principles and the findings of research |

### Suggested Topics for Biology I

Two main curriculum approaches to teaching Bilogy I require different organizations of the content. A phylogenetic approach organizes the content according to the increasing complexity of the organisms. A systemic approach organizes content according to major biological themes such as the biosphere, energy systems, and diversity of organisms and emphasizes their interrelationships.

The following list of suggested topics is not meant to exemplify either the phylogenetic or systemic approach. The topics are listed in random order and, according to teacher discretion, may not necessarily receive equal emphasis.

**Important Scientific Discoveries of the Past and the Relationships of These Activities to Modern Biological Advancements**

**Interactions of Organisms with their Environments**

ecosystems
biomes
succession

**Specialization and Functions of Cellular Organelles**
- nucleus
- cytoplasm
- cell wall
- cell membrane

**Energy Production, Transformation, and Utilization within Living Cells**
- photosynthesis
- cellular respiration
- Krebs cycle
- fermentation

**Principles of Genetics and Heredity**
- Mendel's genetic work
- theory of inheritance
- probability
- multiple alleles
- gene linkage
- recombinant DNA

**Relation of Major Body Systems of Organisms and their Functional Characteristics**
- muscular
- skeletal
- respiratory
- digestive
- circulatory
- nervous
- reproductive
- endocrine
- integumentary

**Diversity of Living Organisms**
- Kingdom Plantae
- Kingdom Animalia
- Kingdom Protista
- Kingdom Monera
- Kingdom Fungi

**Viruses**

**Applications of Biological Principles and Concepts to Everyday Life**

## Biology II

**Biology II is the study of general biological principles as well as of the more specialized biological sciences. Cytology, biochemistry, developmental biology, genetics, ecology, taxonomy, and various aspects of adaptation are integrated within the course. Relationships and applications of concepts within and among the various sciences are explored. As an advanced course, Biology II has as recommended prerequisites Biology I and Chemistry I. Biology II and Chemistry I may be taken concurrently. Biology II may be offered as a regular course, as an honors course, and for advanced placement. Students acquire data by using their senses and instrumentation. Student investigations should emphasize accurate observations, collection of data, data analysis, and the safe manipulation of laboratory apparatus and materials in the laboratory and field.**

## Biology II (1 unit)

| **Essential elements** | **Subelements** |
|---|---|
| Biology II shall be a laboratory-oriented course and shall include the following essential elements: | The student shall be provided opportunities to: |
| (1) Manipulative laboratory skills | demonstrate the safe use of biological equipment and chemicals |
| (2) The use of skills in acquiring data through the senses | (A) observe complex biological phenomena<br>(B) explore biological processes |
| (3) The use of classification skills in ordering and sequencing data | (A) classify biological organisms according to similarities and differences<br>(B) sequence a biological investigation |
| (4) Experience in oral and written communication of data in appropriate form | explain complex biological processes |
| (5) Experience in concepts and skills of measurement using relationships to standards | (A) measure biological data<br>(B) plot data on graphs and displays |
| (6) The use of skills in drawing logical inferences, predicting outcomes, and forming generalized statements | (A) predict the outcome of a biological activity using trends in data<br>(B) formulate a biological hypothesis |
| (7) Experience in skills in relating objects and events to other objects and events | (A) analyze growth rates under varied conditions<br>(B) compare biological functions in selected organisms<br>(C) compare adaptations of organisms to environmental changes |
| (8) Experience in applying defined terms based on observations | clarify operational definitions used in explaining advanced-level biological principles |

## Biology II, *continued*

| Essential elements | Subelements |
|---|---|
| Biology II shall be a laboratory-oriented course and shall include the following essential elements: | The student shall be provided opportunities to: |
| (9) Experience in identifying and manipulating the conditions of investigations | (A) identify the variables remaining constant, the variables being manipulated, and the variables responding in an investigation in advanced-level biology<br>(B) manage an experimental design to test an advanced-level biological hypothesis |
| (10) Application of science in daily life | (A) apply biological principles to medical science and to technology<br>(B) evaluate the applications and career implications of biology principles and the findings of research |

### Suggested Topics for Biology II

Two main curriculum approaches to teaching Biology II require different organizations of the content. A phylogenetic approach organizes the content according to the increasing complexity of the organisms. A systemic approach organizes content according to major biological themes such as the biosphere, energy systems, and diversity of organisms and emphasizes their interrelationships.

The following list of suggested topics is not meant to exemplify either the phylogenetic or systemic approach. The topics are listed in random order and, according to teacher discretion, may not necessarily receive equal emphasis.

**Scientific Discoveries Relating to Modern Biological Advancements**
- confirmation and articulation of the DNA structure
- organ transplants
- artificial organs and life support systems

**Cellular Biology**
- biochemical functions of carbohydrates, sugars, amino acids, proteins, lipids, fats, and enzymes
- structure and function of cells
- active and passive transport
- energy transformations
- reproduction
- protein synthesis

**Structures and Functions on a Comparative and Developmental Basis**
- Kindom Fungi
- Kingdom Monera
- Kingdom Protista
- Kingdom Animalia
- Kingdom Plantae

**Viruses**

**Principles of Genetics**
- Mendelism genetics
- molecular genetics
- human genetics
- population and heredity
- recent genetic advances: genetic engineering, genetic counseling

**Interactions of Organisms with their Environments**
- ecosystems and communities
- population dynamics
- biomes
- energy flow
- succession

**People's Environment**
- conservation
- utilization of resources

## Physiology and Anatomy

Physiology and Anatomy is a laboratory-oriented course in which students investigate the structures and functions of the components of the human body. The course presents investigation of the specialization of cells, how cells function cooperatively as tissue and organs, and the interrelationships of systems that result in a living organism. The course offers students opportunities to investigate anatomical structures and regulating mechanisms that influence how systems function. These concepts may be reinforced through application in a medical facility. The course is designed to build a knowledge base for those students who wish to pursue a medically related career. As an advanced course, Physiology and Anatomy has one unit of Biology I as a recommended prerequisite.

## Physiology and Anatomy (½-1 unit)

| Essential elements | Subelements |
|---|---|
| Physiology and Anatomy shall be a laboratory-oriented course and shall include the following essential elements: | The student shall be provided opportunities to: |
| (1) Manipulative laboratory skills | (A) demonstrate the safe use of laboratory chemicals and equipment<br>(B) demonstrate laboratory techniques of preparing dry- and wet-mount slides |
| (2) The use of skills in acquiring data through the senses | (A) observe anatomical structures<br>(B) examine physiological systems |
| (3) The use of classification skills in ordering and sequencing data | classify anatomical structures according to their physiological functions |
| (4) Experience in oral and written communication of data in appropriate form | (A) describe the physiological functions of selected anatomical structures<br>(B) explain the organization of body function |
| (5) Experience in concepts and skills of measurement using relationships to a standard | (A) measure experimental data (mass and volume of specimens)<br>(B) plot data on graphs and other displays |
| (6) The use of skills in drawing logical inferences, predicting outcomes, and forming generalized statements | (A) predict outcomes of physiology and anatomy functions using inferences<br>(B) deduce a physiological inference |
| (7) Experience in skills in relating objects and events to other objects and events | compare anatomical structures to physiological functions |
| (8) Experience in applying defined terms based on observations | clarify operational definitions used in describing physiological systems |

## Physiology and Anatomy, *continued*

| Essential elements<br>Physiology and Anatomy shall be a laboratory-oriented course and shall include the following essential elements: | Subelements<br>The student shall be provided opportunities to: |
|---|---|
| (9) Experience in identifying and manipulating the conditions of investigations | (A) identify the variables held constant, the variables being manipulated, and the variables responding in an investigation in physiology and anatomy<br>(B) manage an experimental design to test an hypothesis in physiology and anatomy |
| (10) Application of science in daily life | (A) apply the principles of physiology to human health and well-being<br>(B) evaluate the applications and career implications of physiology and anatomy principles and the findings of research |

## Suggested Topics for Physiology and Anatomy

**Cellular Processes**
- physical makeup
- chemical makeup
- cellular components
- cellular specialization and function

**Skeletal System**
- shapes of bones
- growth and development of bones
- structure and function of skeletal system
- abnormalities of the skeletal system
- classification of joints
- function of joints

**Muscular System**
- types of muscles
- growth and development of muscles
- attachment of muscles
- function of muscles
- mechanism of contraction
- chemistry of contraction
- stimulus response function
- muscle tone
- muscle fatigue
- abnormalities of the muscle system

## Environmental Science

Environmental Science is an interdisciplinary course in which students relate and apply concepts and principles from the physical and biological sciences to the environment. Curriculum planners should organize Environmental Science according to local students' interests and needs. Thus, organization of the course may emphasize one or more of the following areas:

- environmental health science
- ecology
- conservation of natural resources
- energy systems

Experiments should be provided that stress the relationships and responsibilities of humans to their environment. Students make observations and collect data in the field and laboratory. Emphasis is placed on resourses in and around the students' community.

## Environmental Science (½-1 unit)

| Essential elements | Subelements |
|---|---|
| Environmental Science shall be a laboratory-oriented course and shall include the following essential elements: | The student shall be provided opportunities to: |
| (1) Manipulative laboratory skills | (A) demonstrate the safe use of environmental science laboratory/field equipment<br>(B) demonstrate proper laboratory/field techniques in environmental science |
| (2) The use of skills in acquiring data through the senses | (A) observe food webs, chains, and pyramids in the environment<br>(B) examine environmental science principles |
| (3) The use of classification skills in ordering and sequencing data | (A) classify environmental science objects, actions, or events according to similarities and differences<br>(B) sequence an environmental science investigation |
| (4) Experience in oral and written communication of data in appropriate form | (A) describe the effects of pollutants on the ecological balance<br>(B) interpret long-term effects of the use of insecticides |
| (5) Experience in concepts and skills of measurement using relationships to standards | (A) measure environmental science quantities<br>(B) plot data on graphs and other displays |
| (6) The use of skills in drawing logical inferences, predicting outcomes, and forming generalized statements | predict an outcome of an environmental science activity from trends in data |

## Environmental Science, *continued*

| Essential elements | Subelements |
|---|---|
| Environmental Science shall be a laboratory-oriented course and shall include the following essential elements: | The student shall be provided opportunities to: |
| (7) Experience in skills in relating objects and events to other objects and events | (A) compare environmental populations under varying conditions<br>(B) contrast the factors that influence the current supply of natural resources |
| (8) Experience in applying defined terms based on observations | clarify operational definitions used in explaining environmental science principles |
| (9) Experience in identifying and manipulating the conditions of investigations | (A) identify the variables remaining constant, the variables being manipulated, and the variables responding in an investigation in environmental science<br>(B) choose an experimental design to test an hypothesis in environmental science |
| (10) Application of science in daily life | (A) analyze human dependence on the environment<br>(B) evaluate the applications and career implications of environmental science principles and the findings of research |

### Suggested Topics for Environmental Science

The following topics need not receive equal attention. Special emphasis should be given to the selected topics to best fill the intent of the course.

**Major Ecosystems**

**Energy Flow in the Environment**

**Natural Cycles (e.g., water, nutrients, $CO_2$, $N_2$)**

**Species: Their Benefits, Liabilities, Control, and Future Prospects**

**Management of Endangered Species**

**Environmental Change**

**Population: Growth, Carrying Capacity, Sociological Factors**

**Environmental Ethics**

**Natural Resources**

**Land Use and Management**

**Water Use and Management**

**Air Quality Management**

**Weather and Climate**

**Fuels: Consumption, Production, and Pollution**

**Waste Management (Solid Waste, Sewage, Chemical)**

**Food Resources**

## Marine Science

Marine Science is a laboratory-oriented, interdisciplinary course that covers concepts from biology, chemistry, physics, geology, meteorology, mathematics, aquatic resources, engineering, and geography of both fresh and salt water as they relate to the marine environment. Knowledge gained from this study can be used in solving problems arising in the operation of fisheries, aquatic farms, agriculture, waste disposal and sanitation, water supply, and navigation; in determining legalities of boundaries; and in many other activities. As a profession, marine science requires broad interests, numerous skills, and an enjoyment of the aquatic environment.

## Marine Science (½-1 unit)

| Essential elements | Subelements |
|---|---|
| Marine Science shall be a laboratory-oriented course and shall include the following essential elements: | The student shall be provided opportunities to: |
| (1) Manipulative laboratory skills | (A) demonstrate the safe use of oceanographic laboratory/field equipment<br>(B) demonstrate laboratory/field techniques of investigation in marine science |
| (2) The use of skills in acquiring data through the senses | (A) observe marine organisms<br>(B) explore selected cycles found in marine environments |
| (3) The use of classification skills in ordering and sequencing data | (A) classify marine organisms according to similarities and differences<br>(B) sequence a marine science investigation |
| (4) Experience in oral and written communication of data in appropriate form | describe marine science processes and ecological patterns |
| (5) Experience in concepts and skills of measurement using relationships to standards | (A) measure marine science data<br>(B) plot data on graphs and other displays |
| (6) The use of skills in drawing logical inferences, predicting outcomes, and forming generalized statements | (A) predict an outcome of a marine science activity using inference<br>(B) formulate a marine science hypothesis |
| (7) Experience in skills in relating objects and events to other objects and events | (A) compare biological processes in selected marine organisms<br>(B) evaluate the impact that oil spills have on intertidal environments<br>(C) compare geologic time in relation to life forms and events |
| (8) Experience in applying defined terms based on observations | clarify operational definitions used in explaining marine science principles |

## Marine Science, *continued*

| Essential elements | Subelements |
|---|---|
| Marine Science shall be a laboratory-oriented course and shall include the following essential elements: | The student shall be provided opportunities to: |
| (9) Experience in identifying and manipulating the conditions of investigations | (A) identify the variables remaining constant, the variables being manipulated, and the variables responding in an investigation in marine science<br>(B) choose an experimental design to test an hypothesis in marine science |
| (10) Application of science in daily life | evaluate the applications and career implications of marine science principles and the findings of research |

### Suggested Topics for Marine Science

**Properties**

- temperature
  - heat capacity
  - gradients
  - freezing—salt water, sea ice
  - evaporation
- density and salinity
  - salinity and density
  - temperature and density
  - evaporation and density
  - salinity in Texas bays
  - interaction of fresh and salt water intrusions
- light penetration
  - turbidity
  - differential absorption of spectrum
  - photosynthetic zone
  - zonation of organisms related to light
- sound
  - travel
  - reflection
  - sonar
  - military
  - marine organism sounds
- pressure
  - factors that affect pressure
  - gases used in diving
  - effects on and adaptations of organisms
- evaporation
  - factors that affect evaporation
  - rates of evaporation on the Gulf Coast
- conductivity
  - thermal and electrical conductivity
  - corrosion—causes and effects of corrosion

**Chemical Properties of Water**
- composition
- recovering minerals

**Physical Processes**
- movement of water
  - currents: horizontal and vertical
  - causes of currents: wind, density gradient, Coriolis effect
  - harnessing currents for energy
- tides
  - lunar cycles
  - tide variation along coast
  - effects of basin, wind, slope
  - harnessing tide energy
  - fishing
- waves
  - wave characteristics and types
  - wind generated
  - seismic generated
- climates
  - Texas coastal climatic zones
  - world climatic zones
  - currents' effects on climate
  - climatic influence on organisms
  - climatic zones' effects on ports
  - violent weather
  - atmosphere and ocean interaction—El Nino

**Geological Features and Processes**
- historical oceanography
- topography of ocean floor
- geology of Gulf of Mexico and its shoreline
- erosion in relation to longshore currents
- barrier islands
- resources
  - energy
  - minerals
- transportation waterways, ports
  - intracoastal waterway
  - inland waterways
- human alterations: dredging, jetties, groins, bulkheads, piers
- water
  - pelagic
  - benthic
- land
  - soft substrates
  - hard substrates
    - artificial
    - natural
- recreation
  - economics
  - navigation
  - seamanship
  - boating
  - swimming
  - scuba diving
  - skiing

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**Classification of Plants and Animals**
- movement—plankton, nekton, benthos
- producer/consumer

**Abiotic Factors Affecting Organisms**
- waves
- tides
- currents
- temperature
- light
- pressure
- salinity
- nutrients

**Biotic Factors Affecting Organisms**
- mutualism
- commensalism
- parasitism
- predator/prey
- food chains and food web
- life cycles of organisms

**Physiological Processes of Selected Organisms**
- photosynthesis
- bioluminescence
- osmoregulation

**Gulf Habitat**
- sandy beach
- rock jetty and groins
- dunes
- open water
- reefs

**Estuarine Habitat**
- oyster reefs
- sea grass
- salt marsh
- open water
- mud flats

**People on the Texas Gulf Coast**
- demographics
- food
- transportation
- energy
- land use
- pollution
- violent weather
- recreation
- responsible behavior

**Resources from the Sea**
- food
- mariculture
- seafood preparation
- medicine
- consumer related problems

**Law of the Sea**

state game and fish laws
federal laws
international agreements

**Research and Exploration**

## Introductory Physical Science

Introductory Physical Science presents a study of the physical and chemical interactions of matter for the low aptitude and/or low interest student. The course presents the fundamental concepts of physics and chemistry and their use in everyday life. Laboratory activities are especially important because they provide concrete representations of abstract concepts and reinforce learning. Teachers should choose and direct activities in a manner that assures the students' success in understanding and applying concepts presented. Emphasis is placed on consumer skills, career opportunities, environmental impact of personal actions, and societal issues.

## Introductory Physical Science (1 unit)

| Essential elements | Subelements |
|---|---|
| Introductory Physical Science shall be a laboratory-oriented course and shall include the following essential elements: | The student shall be provided opportunities to: |
| (1) Manipulative skills | (A) acquire competencies essential for handling selected materials to accomplish personal goals<br>(B) acquire competencies in the use of materials applicable to a variety of physics and chemistry careers (technicians, skilled trades)<br>(C) develop skills essential for using and maintaining the technological materials and devices encountered as a consumer<br>(D) acquire physics- and chemistry-related skills that provide enjoyment in recreational and avocational activities<br>(E) develop skills in using materials and devices in a manner that minimizes danger to self and to society and maintains an acceptable level of erosion of the environment (safety practices, waste disposal) |
| (2) Rational thinking skills in science | (A) organize thought processes to accomplish goals (applications of electronics, photography)<br>(B) evaluate physics and chemistry career choices and prerequisites<br>(C) evaluate endorsements, advertisements, products, and services (photography equipment, electronic equipment, and appliances)<br>(D) make logical decisions concerning the wise use of leisure time and materials (amateur radio, model aircraft)<br>(E) adjust constructively to variations in needs resulting from individual differences that exist both within and among cultures in a healthy society |

## Introductory Physical Science, *continued*

| Essential elements | Subelements |
|---|---|
| Introductory Physical Science shall be a laboratory-oriented course and shall include the following essential elements: | The student shall be provided opportunities to: |
| (3) Science knowledge | (A) discuss scientific information needed to maintain mental and physical health to achieve fulfillment in the environment<br>(B) evaluate information concerning the kinds of physics- and chemistry-related careers available and their prerequisites<br>(C) use physics and chemistry principles and concepts to make reasonable technological applications to the materials and devices encountered in daily life (appliances, modes of transportation, sporting equipment)<br>(D) develop physical science knowledge and pursuit of personal interests during free time (model building, home maintenance)<br>(E) identify information concerning the interactions of science, technology, and society from an historical and contemporary perspective |
| (4) Applications of science | (A) develop belief and confidence in self to control part of the environment<br>(B) perceive physics- and chemistry-related career choices as being of value to self and society (technician, skilled trades)<br>(C) consider the consequences of personal actions (safety, chemical disposal)<br>(D) develop a sense of personal worth in doing things for pleasure as well as in doing for others (hobbies)<br>(E) acquire awareness and a sense of desirability of applying scientific knowledge in a manner that results in optimum benefit for people (energy sources, conservation) |

## Suggested Topics for Introductory Physical Science

**Energy**
- heat
- mechanical
- chemical
- electromagnetic

**Sound**

**Matter**
- properties
- atomic structure
- chemical nature

**Nuclear Chemistry**

**Carbon and Its Compounds**

**Electricity and Magnetism**

**Motion**

**Waves**

**Work and Energy**

**Chemistry**
- household compounds: use, storage, and disposal
- gardening compounds: use, storage, and disposal

**Physics**
- toys
- tools
- equipment

## Physical Science

Physical Science presents a study of the physical and chemical interactions of matter. The course is divided into two semesters. One semester covers introductory concepts in chemistry; the other, introductory concepts in physics. The course stresses an operational understanding of the basic concepts in selected topics rather than a less thorough study of numerous topics. Students acquire data by using their senses and instrumentation. Student laboratory investigations emphasize accurate observations, collection of data, data analysis, and the safe manipulation of laboratory apparatus and materials in the laboratory.

## Physical Science (1 unit)

| Essential elements | Subelements |
|---|---|
| Physical Science shall be a laboratory-oriented course and shall include the following essential elements: | The student shall be provided opportunities to: |
| (1) Manipulative laboratory skills | demonstrate the safe use of physical science laboratory equipment and selected chemicals |
| (2) The use of skills in acquiring data through the senses | (A) observe physical and chemical properties of matter<br>(B) observe the effects of forces on matter<br>(C) explore magnetic and electrical interactions |
| (3) The use of classification skills in ordering and sequencing data | classify chemicals according to similarities of properties |
| (4) Experience in oral and written communication of data in appropriate form | (A) describe physical and chemical interactions<br>(B) discuss the factors that affect the motions of objects |
| (5) Experience in concepts and skills of measurement using relationships to standards | (A) measure physical and chemical quantities<br>(B) plot data on graphs and other displays |
| (6) The use of skills in drawing logical inferences, predicting outcomes, and forming generalized statements | (A) formulate a physical science hypothesis<br>(B) predict the outcome of a physical science activity from trends in data using inference, extrapolation, or interpolation |
| (7) Experience in skills in relating objects and events to other objects and events | (A) compare models of atoms and machines<br>(B) compare and contrast chemicals according to their properties<br>(C) compare objects according to their properties |

## Physical Science, *continued*

| Essential elements | Subelements |
|---|---|
| Physical Science shall be a laboratory-oriented course and shall include the following essential elements: | The student shall be provided opportunities to: |
| (8) Experience in applying defined terms based on observations | clarify operational definitions used in explaining precipitation, acid-base indicators, force meters, electroscopes, and simple machines |
| (9) Experience in identifying and manipulating the conditions of investigations | (A) identify the variables remaining constant, the variables being manipulated, and the variables responding in physical science investigations<br>(B) manage an experimental apparatus to test a physical science hypothesis |
| (10) Application of science in daily life | (A) analyze the use of chemicals in everyday activities of the home and industry<br>(B) apply alternative sources of energy to work<br>(C) evaluate the applications and career implications of physical science principles and the findings of research |

### Suggested Topics for Physical Science

**Matter**
- properties
- classification
- particle theory
- physical and chemical changes

**Atomic Structure**
- molecules and compounds
- atoms and atomic particles
- elements and the periodic chart

**Chemical Nature of Matter**
- chemical bonding/reactions
- chemistry of common materials
- acid, base, and salt theory

**Electricity**
- as explained by atomic theory
- voltage
- current
- power
- measurement
- static electricity

**Magnetism**
- magnetic poles
- magnetic fields
- electromagnetism
- induction

**Heat Energy**
- heat transfer
- temperature
- cooling systems

**Motion**
- linear motion
- circular motion
- laws of motion
- gravitation

**Work and Energy**
- forces and work
- simple machines
- work and efficiency
- power

**Waves**
- types of waves
- properties of waves
- reflection
- diffraction
- refraction

**Sound**
- nature of sound
- properties (pitch, frequency, amplitude)
- standing waves

**Electromagnetic Energy**
- electromagnetic spectrum (light, radio)
- wave and particle nature of electromagnetic spectrum
- reflection, refraction, diffraction

**Nuclear Chemistry**
- radioactivity
- nuclear energy
- nuclear reactions

## Chemistry I

Chemistry is the study of the structure, composition, and behavior of matter. The course of study emphasizes the investigation of matter, its interactions, and the factors affecting the interactions. Chemistry I is a laboratory-oriented course that stresses the observation of matter and its behavior, classification of matter, communication of data, measurement of chemical quantities, prediction of chemical phenomena, and manipulation of chemical investigations. Students acquire data by using their senses and instrumentation. The investigations emphasize accurate observations, collection of data, data analysis, and the safe manipulation of laboratory apparatus and materials.

## Chemistry I (1 unit)

| Essential elements | Subelements |
|---|---|
| Chemistry I shall be a laboratory-oriented course and shall include the following essential elements: | The student shall be provided opportunities to: |
| (1) Manipulative laboratory skills | demonstrate the safe use of chemical laboratory equipment and supplies |
| (2) The use of skills in acquiring data through the senses | (A) observe chemical reactions<br>(B) explore the factors governing the rate of a chemical change |
| (3) The use of classification skills in ordering and sequencing data | (A) classify chemical reactions of substances according to similarities and differences in properties<br>(B) sequence a qualitative analysis scheme |
| (4) Experience in oral and written communication of data in appropriate form | (A) describe chemical processes<br>(B) explain meaningful arrangements of chemical information |
| (5) Experience in concepts and skills of measurement using relationships to standards | (A) measure chemical quantities (reacting mass ratios, reacting volume ratios, effects of catalysts, effects of temperature)<br>(B) plot data on graphs and other displays |
| (6) The use of skills in drawing logical inferences, predicting outcomes, and forming generalized statements | (A) predict an outcome from trends in chemical data using inference, extrapolation, or interpolation<br>(B) formulate a chemical hypothesis |
| (7) Experience in skills in relating objects and events to other objects and events | (A) compare models of chemical and nuclear reactions<br>(B) contrast the chemical properties of materials<br>(C) compare atomic structures of simple elements |

## Chemistry I, *continued*

| Essential elements | Subelements |
|---|---|
| Chemistry I shall be a laboratory-oriented course and shall include the following essential elements: | The student shall be provided opportunities to: |
| (8) Experience in applying defined terms based on observations | clarify operational definitions used in explaining chemical and nuclear processes |
| (9) Experience in identifying and manipulating the conditions of investigations | (A) identify the variables remaining constant, the variables being manipulated, and the variables responding in a chemistry investigation<br>(B) manage an experimental apparatus to test a chemical hypothesis |
| (10) Applications of science in daily life | (A) explain the application of chemical and nuclear processes<br>(B) evaluate the applications and career implications of chemistry and nuclear principles and the findings of research |

## Suggested Topics for Chemistry I

**Measurement**

units of measurement
significant figures
factor-label method
exponential notation

**Matter and Energy**

classification: homogeneous, heterogeneous, solutions, mixtures, elements, compounds
states: gases, liquids, solids
phase changes
density
change in matter: physical and chemical
kinetic and potential energy
forms of energy: heat, electrical, radiant, nuclear, chemical, mechanical
exothermic and endothermic reactions
measurement of heat quantities

**Atomic Structure**

subatomic particles
concepts of atomic mass and mass number
nature of light and radiation
models of atomic structure: Dalton, Bohr, Rutherford, wave-mechanical
electronic configurations
atomic mass unit
equivalence of mass and energy

**Chemical Bonding**
- valence electrons
- electron dot diagrams
- ionic bonding
- metallic bonding
- covalent bonding
- hybridization
- polyatomic ions
- bond strength
- electronegativity and bond polarity
- polar and non-polar molecules
- attractive forces between atoms: hydrogen bonding, van der Waals

**Periodicity**
- periodic law
- arrangement of periodic table
- periodic trends: electronegativity, atomic radii, ionization energy

**Formulas and Equations**
- empirical and molecular formulas
- mole concept
- writing a chemical equation
- nomenclature

**Solids and Liquids**
- physical properties
- crystalline solids

**Gases**
- Ideal Gas Law
- Boyle's Law
- Charles' Law
- Dalton's Law
- Graham's Law
- kinetic theory

**Solutions**
- solute and solvent
- types of solutions
- solubility
- factors affecting solubility
- saturated, unsaturated, and supersaturated solutions
- solution concentrations
- colligative properties

**Kinetics and Equilibrium**
- rate of reaction
- activation energy
- catalysts
- enthalpy
- entropy
- reversible reactions
- equilibrium constant
- Le Chatelier's principle
- solubility product constant and expression

**Acids, Bases, and Salts**

- electrolytes and nonelectrolytes
- theory of ionization
- ionization constants for acids and bases
- definitions of acid and base
- pH and pOH
- buffers
- acid/base titration

**Electrochemistry**

- oxidation numbers
- balancing oxidation-reduction reactions
- electrolysis
- galvanic cells

**Nuclear Chemistry**

- natural and artificial radioactivity
- types of radiation
- accelerators and reactors
- nuclear applications

## Chemistry II

Chemistry II is an in-depth study of chemical concepts and principles encountered in Chemistry I. It also integrates the specialized areas of chemistry such as organic chemistry, quantitative and qualitative analysis, and nuclear chemistry. Chemistry II is an advanced course with recommended prerequisites of Chemistry I and Physics I; the latter may be taken concurrently with Chemistry II. Chemistry II may be offered as a regular course, an honors course, and for advanced placement. Student investigations emphasize accurate observations, collection of data, data analysis, and the safe manipulation of laboratory apparatus and materials.

The laboratory program in Chemistry II should present both confirmatory activities and inquiry investigations. The student should have experience in glassworking, filtrating, titrating, weighing, collecting and handling gases, selecting and arranging apparatus, and designing some experiments. Through laboratory experiences, students should gain an operational definition of the concepts and principles of chemistry. Some of the laboratory work should include the analysis of unknowns through a variety of laboratory procedures.

## Chemistry II (1 unit)

| Essential elements | Subelements |
|---|---|
| Chemistry II shall be a laboratory-oriented course and shall include the following essential elements: | The student shall be provided opportunities to: |
| (1) Manipulative laboratory skills | (A) demonstrate the safe use of advanced-level chemistry laboratory equipment and supplies<br>(B) demonstrate advanced-level chemistry laboratory techniques |
| (2) The use of skills in acquiring data through the senses | (A) observe advanced-level chemical reactions<br>(B) explore advanced-level chemical reaction rates |
| (3) The use of classification skills in ordering and sequencing data | (A) classify advanced-level chemical reactions according to similarities and differences<br>(B) sequence a chemical investigation |
| (4) Experience in oral and written communication of data in appropriate form | (A) describe advanced-level chemical reactions and their stoichiometry<br>(B) explain chemical reactions and kinetics |
| (5) Experience in concepts and skills of measurement using relationships to standards | (A) measure advanced-level chemical quantities<br>(B) plot data on graphs and other displays |
| (6) The use of skills in drawing logical inferences, predicting outcomes, and forming generalized statements | predict an outcome of a chemical investigation from trends in data using inference, extrapolation, or interpolation |

## Chemistry II, *continued*

| Essential elements | Subelements |
|---|---|
| Chemistry II shall be a laboratory-oriented course and shall include the following essential elements: | The student shall be provided opportunities to: |
| (7) Experience in skills in relating objects and events to other objects and events | (A) compare models of chemical and nuclear reactions<br>(B) evaluate chemical reaction rates under varied conditions |
| (8) Experience in applying defined terms based on observations | clarify operational definitions used in explaining advanced-level chemical and nuclear processes |
| (9) Experience in identifying and manipulating the conditions of investigations | (A) identify the variables remaining constant, the variables being manipulated, and the variables responding in an investigation in advanced-level chemistry<br>(B) manage an experimental design to test an advanced-level chemical hypothesis |
| (10) Application of science in daily life | (A) explain the applications of chemical and nuclear processes<br>(B) evaluate the applications and career implications of chemistry and nuclear principles and the findings of research |

### Suggested Topics for Chemistry II

**Atomic Theory**

- evidence for atomic theory
- atomic weights
- empirical formulae from experimental data
- atomic weight determinations
- atomic number
- isotopes
- mass spectroscopy
- electron energy levels
- quantum numbers
- atomic spectra
- periodic law
- electronegativity

**Chemical Bonds**

- types of bonds
- polarity of bonds
- bond strengths
- molecular geometry
- isomerism

molecular weight determinations using freezing point depression and boiling point elevation
resonance
hybridization of orbitals

**Nuclear Chemistry**
mass-energy equivalence
transmutation
radioactivity
fission
fusion
half-life

**Gases**
ideal gas laws
behavior of real gases
Graham's Law
molecular weight determinations using Graham's law and gas density
kinetic-molecular theory
van der Waal's forces

**Liquids and Solids**
physical properties of solids and liquids
phase diagrams of one-component systems
liquification of gases

**Solutions**
concentration units
mole fraction
phase diagrams of two-component systems
Raoult's law
colligative properties

**Acids and Bases**
acid-base reactions
Arrhenius theory
Bronsted-Lowry theory
Lewis theory
complex ion formation
amphoterism

**Oxidation-Reduction Reactions**
oxidation number
standard electrode potential
prediction of direction of oxidation-reduction reactions
electrolytic cells
voltaic cells
Faraday's laws

**Equilibrium**
Le Chatelier's principle
equilibrium constants in terms of molar concentrations
equilibrium constants in terms of partial pressures
ionization constants for acids and bases
common ion effect on equilibrium
buffers
complexion formation
solubility product constants

**Kinetics**

- rate of reaction
- order of reaction
- effect of change in temperature on reaction rate
- role of a catalyst
- rate determining step of a reaction

**Thermodynamic Relations**

- heat of formation
- heat of reaction
- total heat content
- latent heat of fusion
- latent heat of vaporization
- heat capacity
- free energy of formation
- relation of free energy to reaction spontaneity
- entropy

**Descriptive Chemistry**

- periodic law
- typical chemical families
- relation of atomic radii to ionization potential
- relation of atomic radii to electronegativity
- relation of structure to the reactions of selected organic compounds

## Physics I

Physics is the study of matter and energy and their interactions. Students are introduced to fundamental concepts in the areas of mechanics, light, sound, heat, electricity, magnetism, and nuclear phenomena. Students acquire information using the senses and instrumentation. Observations of the laws of force and motion, the nature of light, wave phenomena, and properties of electricity and magnetism are integral components of the course. Student investigations emphasize accurate observations, collection of data, analysis of data, and the safe manipulation of laboratory apparatus and materials.

## Physics I (1 unit)

| Essential elements | Subelements |
|---|---|
| Physics I shall be a laboratory-oriented course and shall include the following essential elements: | The student shall be provided opportunities to: |
| (1) Manipulative laboratory skills | demonstrate the safe use of physics laboratory equipment and supplies |
| (2) The use of skills in acquiring data through the senses | observe physics phenomena |
| (3) The use of classification skills in ordering and sequencing data | (A) classify physical interactions according to similarities<br>(B) sequence a physics investigation |
| (4) Experience in oral and written communication of data in appropriate form | describe physical processes |
| (5) Experience in concepts and skills of measurement using relationships to standards | (A) measure physical quantities<br>(B) plot data on graphs and other displays |
| (6) The use of skills in drawing logical inferences, predicting outcomes, and forming generalized statements | (A) predict the outcome of a physics investigation from trends in data using inference, extrapolation, or interpolation<br>(B) deduce a physics hypothesis from cause-and-effect relationships |
| (7) Experience in skills in relating objects and events to other objects and events | (A) evaluate scale models of vector problems<br>(B) compare the functions of electronic circuits<br>(C) compare the electrical efficiency of appliances |
| (8) Experience in applying defined terms based on observations | clarify operational definitions used in explaining physics processes |

## Physics I, *continued*

| Essential elements | Subelements |
|---|---|
| Physics I shall be a laboratory-oriented course and shall include the following essential elements: | The student shall be provided opportunities to: |
| (9) Experience in identifying and manipulating the conditions of investigations | (A) identify the variables remaining constant, the variables being manipulated, and the variables responding in an investigation in physics<br>(B) choose an experimental design to test an hypothesis in physics |
| (10) Application of science in daily life | (A) apply principles of physics to an investigation<br>(B) evaluate the applications and career implications of physics principles and the findings of research |

### Suggested Topics for Physics I

**Fundamental Physical Quantities**
- characteristics of fundamental physical quantities: mass, time

**Vectors and Scalars**
- characteristics
- representations
- mathematical operations

**Kinematics**
- characteristics of motion
- speed
- rectilinear velocity
- rectilinear acceleration
- circular motion

**Dynamics**
- characteristics of dynamics
- forces
- friction
- gravity
- impulse and momentum

**Mechanical Energy**
- characteristics of energy
- work
- kinetic energy
- potential energy
- conservation of energy

**Machines**
- characteristics of machines
- simple machines
- mechanical advantage

**Properties of Matter**
- characteristic properties of matter
- solids, liquids, and gases
- elasticity
- hydrostatics
- hydrodynamics

**Heat and Thermodynamics**
- characteristics of heat and thermodynamics
- temperature
- thermal expansion and contraction
- quantity of thermal energy
- change of state
- transfer of heat
- thermodynamics

**Waves**
- characteristics of waves
- reflection
- refraction
- diffraction
- interference of waves

**Sound**
- characteristics of sound
- transmission of sound
- reflection and absorption of sound
- intensity of sound
- frequency of sound

**Light** (electromagnetic radiation)
- characteristics of light
- photometry
- color
- photoelectric effect

**Electricity**
- characteristics of electricity
- electrostatics
- electrical forces
- potential differences
- electric current
- electric circuits
- electrical energy

**Magnetism**
- characteristics of magnetism
- magnetic forces
- electromagnetism
- electromagnetic induction
- generators and motors
- alternating current circuits

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**Atomic Physics**

- characteristics of atomic physics
- subatomic particles
- spectra of elements

**Nuclear Physics**

- characteristics of nuclear physics
- nature of radioactivity
- nuclear reactions
- nuclear energy

## Physics II

Physics II is an in-depth study of physical concepts and principles encountered in Physics I. It also integrates some of the more specialized areas of physics such as nuclear and modern physics. Physics II is a laboratory-oriented course with laboratory investigations conducted in mechanics, optics, heat, electricity, magnetism, radiation, atomic structure, and nuclear phenomena. Students acquire information using the senses and instrumentation. As an advanced course, Physics II has recommended prerequisites of Physics I and Chemistry I; the latter may be taken concurrently with Physics II. The course may be offered as a regular course, an honors course, and for advanced placement.

## Physics II (1 unit)

| Essential elements<br>Physics II shall be a laboratory-oriented course and shall include the following essential elements: | Subelements<br>The student shall be provided opportunities to: |
|---|---|
| (1) Manipulative laboratory skills | (A) demonstrate the safe use of advanced-level physics laboratory equipment and supplies<br>(B) demonstrate advanced-level physics laboratory techniques |
| (2) The use of skills in acquiring data through the senses | (A) observe advanced-level physics reactions<br>(B) examine advanced-level physics processes |
| (3) The use of classification skills in ordering and sequencing data | (A) classify advanced-level physics actions, according to similarities and differences<br>(B) sequence an advanced-level physics investigation |
| (4) Experience in oral and written communication of data in appropriate form | describe advanced-level physics processes |
| (5) Experience in concepts and skills of measurement using relationships to standards | (A) measure advanced-level physics quantities<br>(B) plot data on graphs and other displays |
| (6) The use of skills in drawing logical inferences, predicting outcomes, and forming generalized statements | (A) predict the outcome of a physics activity using trends in data<br>(B) formulate a physics hypothesis |
| (7) Experience in skills in relating objects and events to other objects and events | (A) compare physical interactions under varied conditions<br>(B) evaluate the electrical efficiency of machines |
| (8) Experience in applying defined terms based on observations | demonstrate the use of operational definitions in explaining advanced-level physics processes |

## Physics II, *continued*

| Essential elements | Subelements |
|---|---|
| Physics II shall be a laboratory-oriented course and shall include the following essential elements: | The student shall be provided opportunities to: |
| (9) Experience in identifying and manipulating the conditions of investigations | (A) identify the variables remaining constant, the variables being manipulated and the variables responding in an investigation in advanced-level physics<br>(B) develop and analyze an experimental design to test an advanced-level physics hypothesis |
| (10) Application of science in daily life | evaluate the applications and career implications of physics principles and the findings of research |

### Suggested Topics for Physics II

**Classical Mechanics**
- motion in one dimension
- motion in a plane
- work, energy, and power
- rotational motion
- oscillatory motion
- conservation laws: energy and momentum

**Fluids**
- Pascal's principle
- Archimedes' principle
- Bernoulli's principle

**Waves**
- traveling waves
- superposition, standing waves, and beats
- Doppler effect

**Relativistic Mechanics**
- Galilean vs. Lorentz transformations
- time dilation and length contraction
- kinematics and dynamics

**Thermodynamics**
- kinetic theory
- expansion: isothermal, adiabatic
- measurement of temperature
- first law of thermodynamics
- Cv and Cp
- the second law of thermodynamics
- reversible and irreversible processes
- Carnot cycle

**Electricity and Magnetism**

- electric charge
- Coulomb's law
- electric field
- electric potential
- Gauss' law
- capacitance
- resistance
- potential difference
- Kirchoff's laws for multiloop circuits
- force on a moving charge in a magnetic field
- magnetic field for a long wire, coil, and solenoid
- induced current
- inductance
- resonant circuits and time constants

**Light**

- geometric optics
- interference and diffraction
- polarization
- spectra

**Radioactivity**

- rate of decay
- absorption of nuclear radiation
- biological effects of radiation
- radioactive materials

**Electronics**

- filter circuits
- vacuum tubes
- semiconductors
- integrated circuits
- detectors, oscillators, and amplifiers

## Aerospace-Aviation I

Aerospace-Aviation I is intended to develop the student's basic understanding of the scientific and technological fundamentals involved in the science of flight. An interdisciplinary approach is emphasized with instruction related to the airplane and space vehicle. Topics include the history of aviation, meteorology, physiology of flight and space travel, air traffic control and communications, Federal Aviation Regulations, flight navigation, airplane systems and instruments, aerodynamics, physics of weight and balance, and applications and career implications. The course provides opportunities for students to develop positive attitudes toward science, to use skills in everyday problem solving, and to increase appreciation of the order and complexity of the universe through the use of student experimentation, field studies, demonstrations, and group projects.

Aerospace-Aviation I may serve as the equivalent of a Federal Aviation Administration private pilot ground school and provides preparation for the FAA private pilot written examination.

## Aerospace-Aviation Education I (ground school—½-1 unit)

| Essential elements | Subelements |
|---|---|
| Aerospace-Aviation Education I shall be a laboratory-oriented course and shall include the following essential elements: | The student shall be provided opportunities to: |
| (1) Manipulative laboratory skills | (A) demonstrate the safe use of equipment and materials<br>(B) demonstrate investigative procedures and techniques |
| (2) The use of skills in acquiring data through the senses | (A) observe aerospace phenomena that occur in ordinary flight<br>(B) explore factors that affect a science process used in flight<br>(C) observe the different physical forms of aircraft |
| (3) The use of classification skills in ordering and sequencing data | (A) classify flight instruments<br>(B) classify aircraft function by their physical form |
| (4) Experience in oral and written communication of data in appropriate form | (A) describe the differing power plants used in aircraft<br>(B) describe the application of vectors used in navigation<br>(C) describe the effects of the control surfaces on the motion of the aircraft |
| (5) Experience in concepts and skills of measurement using relationships to standards | (A) measure the effects of different load placements<br>(B) measure navigational properties (air speed, ground speed, azimuth)<br>(C) plot data on graphs and other displays |

## Aerospace-Aviation Education I, *continued*

| Essential elements | Subelements |
|---|---|
| Aerospace-Aviation Education I shall be a laboratory-oriented course and shall include the following essential elements: | The student shall be provided opportunities to: |
| (6) The use of skills in drawing logical inferences, predicting outcomes, and forming generalized statements | (A) predict time of flight for a trip<br>(B) predict the fuel consumption per hour<br>(C) predict the outcome of a control movement<br>(D) predict wind vector, drift, heading, and speed determinations |
| (7) Experience in skills in relating objects and events to other objects and events | (A) analyze scale model of aircraft<br>(B) compare subsonic flight to supersonic flight<br>(C) contrast the types of cabin instruments |
| (8) Experience in applying defined terms based on observations | (A) clarify aircraft maneuvers using operational definitions<br>(B) demonstrate the use of electronic communication in aircraft |
| (9) Experience in identifying and manipulating the conditions of investigations | identify the variables remaining constant, the variables being manipulated, and the variables responding in an investigation in aerospace-aviation education |
| (10) Application of science in daily life | (A) evaluate the design of different aircraft for differing applications<br>(B) analyze the effect of speed and load on fuel consumption rate<br>(C) evaluate the applications of power plant and airframe research in aircraft capabilities<br>(D) evaluate the applications and career implications of aerospace-aviation principles and the findings of research |

### Suggested Topics for Aerospace-Aviation I

**Aviation History**

major events in the history of flight
key contributors to advancements in the development of flight
impact upon society

**Basic Aerodynamics**
- atmospheric science
- theories of flight
  - Bernoulli's Law
  - Newton's three laws of motion, action, reaction
  - gravitational forces, artificial gravity, centrifugal force
  - universal gas laws
  - laminar and turbulent flow
  - three axes
- aerodynamics of lift, thrust, gravity, drag
- velocity characteristics
- drag
- speed of sound versus temperature and pressure
- load factors—mathematics of weight and balance
  - datum, arm, and moment
  - maximum gross weight
  - load placements
  - center of gravity
  - center of lift
  - effects of maneuvers
  - stresses

**Aeronautical Meteorology**
- the atmosphere
- temperature, pressure, and moisture factors
- clouds and fog
- air masses and frontal weather
- wind
- thunderstorms
- turbulence
- prognosis and reports interpretation
- aviation weather charts

**The Nature of Space**

**Magnetism**
- nature of magnet
- earth as a magnet

**Basic Navigation**
- cartographics
- chart interpretation
- navigation plotter
- flight computer—conversions, metrics, interpolation, slide rule techniques
- dead reckoning

**Radio Navigation**
- characteristics and limitations of radio signals—radio waves, sound waves
- very high frequency omnidirectional range stations (VOR)
- automatic direction finding (ADF)
- instrument landing system (ILS)
- radar services
- RNAV and LORAN

**Air Traffic Control, Communications, and Federal Aviation Regulations**

- charting of airports and airways
- air traffic control facilities and procedures
- air traffic patterns
- aircraft communication systems
- Federal Aviation Regulations (FAR)
- flight information publications
- emergency procedures

**Aircraft Systems, Power Plants, and Instruments**

- simple machines and energy conversion
- internal combustion reciprocating engine
  - four-stroke cycle
  - fuel systems
  - supercharger to assist carburetor
  - fuel injection
- turbo and ramjet engines
- fuel, ignition, lubrication, cooling, electrical, and hydraulic systems
- instrumentation and interpretation—gyroscopic applications
  - common engine instruments
  - navigation instruments
  - flight instruments
  - flight computer functions
- flight physiology
  - oxygen, altitude, and the body
  - vertigo and vision
  - motion
- applications and careers

## Aerospace-Aviation II

Aerospace-Aviation II is a laboratory-oriented course that presents a progression of the experiences provided in Aerospace-Aviation I. It is designed for students who have a significant interest in activities related to aviation and aerospace and who, after successful completion of Aerospace-Aviation I, desire further study. Aerospace-Aviation II provides students with an advanced technological orientation as well as a solid foundation on which to build an aerospace-aviation career. It includes an advanced academic program in the classroom and/or a flight training program through private pilot certification. If a flight training program is provided, students will achieve and demonstrate satisfactory performance levels in all skills required in Federal Aviation Regulation Part 61, as applicable to private pilot certification.

Two approaches are suggested for handling the flight training phase of Aerospace-Aviation II. Independent laboratory participation by the student may be required either during specified school hours or outside regular school time. In this arrangement, the student schedules his or her own flight training at a local airport with a qualified, FAA-certified flight instructor. The student attains predetermined levels of achievement and proficiency according to a timetable established by the instructor. The arrangement could be similar to educational performance contracting used in other areas of the curriculum. It would necessitate close liaison between the teacher and flight instructor. Unless other funds are available, the costs of such training would be provided by the student. Flight training may be provided at a local airport through a contractual arrangement between the school district and the airport flight school operator. Financing of training might still be the responsibility of either school or student; however, the contractual agreement could serve to reduce overall flight training costs under predetermined rates.

## Aerospace-Aviation Education II (advanced academic classroom laboratory and flight experience—½-1 unit)

| Essential elements | Subelements |
|---|---|
| Aerospace-Aviation Education II shall be a laboratory-oriented course and shall include the following essential elements: | The student shall be provided opportunities to: |
| (1) Manipulative laboratory skills | (A) demonstrate the safe use of advanced-level equipment and materials<br>(B) demonstrate advanced-level investigative procedures and techniques<br>(C) demonstrate knowledge of F.A.A. regulations |
| (2) The use of skills in acquiring data through the senses | (A) observe aerospace and meteorological phenomena<br>(B) explore aerodynamic theories<br>(C) observe the different types of cabin instruments<br>(D) explore maneuver analysis |
| (3) The use of classification skills in ordering and sequencing data | (A) classify problems of air navigation<br>(B) classify communication systems |
| (4) Experience in oral and written communication of data in appropriate form | (A) describe emergency procedures<br>(B) describe air traffic patterns<br>(C) contrast the effects of meteorological conditions |

## Aerospace-Aviation Education II, *continued*

| Essential elements | Subelements |
|---|---|
| Aerospace-Aviation Education II shall be a laboratory-oriented course and shall include the following essential elements: | The student shall be provided opportunities to: |
| (5) Experience in concepts and skills of measurement using relationships to standards | (A) identify the science principles used in selected instruments<br>(B) measure aerodynamic characteristics of differing airframes |
| (6) The use of skills in drawing logical inferences, predicting outcomes, and forming generalized statements | (A) analyze meteorologic maps for trip planning<br>(B) plot data on graphs and charts<br>(C) predict fuel consumption considering load, air speed, and aircraft design |
| (7) Experience in skills in relating objects and events to other objects and events | (A) contrast output of various aircraft power plants<br>(B) compare instrument settings for various geographical locations<br>(C) analyze radio navigation systems<br>(D) contrast takeoffs and landings on various strip surfaces |
| (8) Experience in applying defined terms based on observations | (A) clarify instrumentation applications using operational definitions<br>(B) demonstrate aircraft maneuvers using operational definitions<br>(C) demonstrate or simulate cross-country flight |
| (9) Experience in identifying and manipulating the conditions of investigations | (A) identify the variables remaining constant, the variables being manipulated, and the variables responding in aerospace-aviation investigations<br>(B) manage an experimental apparatus to test an aerospace-aviation hypothesis |
| (10) Application of science in daily life | (A) evaluate recovery procedures from unusual altitudes<br>(B) analyze maximum performance takeoffs and climbs<br>(C) evaluate precision approaches to airfields<br>(D) evaluate the procedure for obtaining assistance via radio<br>(E) evaluate the applications and career implications of aerospace-aviation principles and the findings of research |

## Suggested Topics for Aerospace-Aviation II

**Classroom**

- directed research studies in the socioeconomic implications of aerospace-aviation progression in our world
- directed research studies in a student- and instructor-selected technical area of aerospace-aviation activities
- aerodynamics theory and analysis
- instruments, systems, and flight relationships
- weight and balance computations
- studies in aeronautical meteorology
- flight computer computations
- problems in air navigation science
- introduction to commercial flight regulations
- primary flight maneuvers analysis
- flight safety

**Flight Laboratory**

- airplane familiarization and inspection
- starting the engine
- radio procedures
- taxiing
- pretakeoff check
- takeoff
- traffic pattern
- climbout
- climbing turns
- straight and level
- glides and gliding turns
- turns to headings
- ground reference maneuvers
- forced landings
- emergency procedures
- accelerated stalls
- crosswind takeoffs and landings
- medium turns
- slow flight
- power-off stalls
- steep turns
- confidence maneuvers
- descents and gliding turns
- approach and landing
- level off from climbs and glides
- coordination exercises
- speed changes in level flight
- slips
- use of flaps
- balked takeoffs
- emergency go-arounds
- turns about a point
- cross-control stalls
- maximum performance takeoff

## Geology

Geology is the study of the earth's history and materials. This course offers students opportunities to investigate the composition of minerals and rocks, the deformations they undergo, and the history of the earth and its past plant and animal inhabitants. Geology applies the principles of physics, chemistry, biology, and mathematics to earth problems. Special emphasis should be placed on building the students' positive attitudes toward their environment and energy conservation.

Among the practical applications are the search for and production of many valuable earth materials such as petroleum, subsurface water, metal ores, coal, and important nonmetallic minerals. The study of geology has numerous applications in engineering, construction work, and agriculture.

Students make observations using their senses and through instrumentation in the field. Laboratory experiences are necessary prerequisites to effective field work. Investigations emphasize accurate observations, collection of data, data analysis, and the safe manipulation of apparatus and materials in the field and laboratory.

## Geology (½-1 unit)

| Essential elements | Subelements |
|---|---|
| Geology shall be a laboratory-oriented course and shall include the following essential elements: | The student shall be provided opportunities to: |
| (1) Manipulative laboratory skills | (A) demonstrate the safe use of geologic equipment and supplies<br>(B) demonstrate field/laboratory techniques of using goggles and selected chemicals in testing minerals |
| (2) The use of skills in acquiring data through the senses | (A) observe geological structures (anticline, syncline, faults)<br>(B) examine earth materials |
| (3) The use of classification skills in ordering and sequencing data | (A) classify earth materials, structures, and phenomena according to similarities and differences in crystal structure, cleavage, and chemical structure<br>(B) sequence a geological investigation |
| (4) Experience in oral and written communication of data in appropriate form | describe earth materials and geologic structures |
| (5) Experience in concepts and skills of measurement using relationships to standards | (A) measure geological quantities<br>(B) plot data on graphs, maps, and other displays |
| (6) The use of skills in drawing logical inferences, predicting outcomes, and forming generalized statements | (A) predict the outcome of a geological investigation from trends in data using extrapolation or interpolation<br>(B) formulate a geological hypothesis |

## Geology, *continued*

| Essential elements | Subelements |
|---|---|
| Geology shall be a laboratory-oriented course and shall include the following essential elements: | The student shall be provided opportunities to: |
| (7) Experience in skills in relating objects and events to other objects and events | (A) compare scale models of geological structures<br>(B) contrast the properties of minerals and fossils<br>(C) compare geologic time in relation to life forms and events |
| (8) Experience in applying defined terms based on observations | clarify operational definitions used in explaining geological processes |
| (9) Experience in identifying and manipulating the conditions of investigations | (A) identify the variables remaining constant, the variables being manipulated, and the variables responding in an investigation in geology<br>(B) choose an experimental design to test a geological hypothesis |
| (10) Application of science in daily life | evaluate the applications and career implications of geology principles and the findings of research |

### Suggested Topics for Geology

**Structure of the Earth**
- interior of earth
- seismic waves

**Major Geologic Features of the Earth**
- types of features
- maps

**Lithosphere**
- minerals
  - classification
  - physical properties
  - crystal symmetry
  - formation of minerals
  - identification of minerals
- rocks
  - igneous
  - sedimentary
  - metamorphic
  - rock cycle

- global tectonics
  - continental drift and sea-floor spreading
  - evidence for plate movement
  - folds, faults, and joints
  - volcanoes
  - mountain buildup
  - earthquakes
- agents of weathering and erosion
  - running water, ground water, wind, glaciers, oceans

**Earth's Resources**
- metallic resources
- nonmetallic resources
- renewable
- nonrenewable

**Hydrosphere**
- origin
- hydrologic cycle
- surface and subsurface water
- oceans
- glaciers

**Atmosphere**
- origin
- natural "pollution"

**Geologic Time**
- cosmogony
- Precambrian era
- Paleozoic era
- Mesozoic era
- Cenozoic era
- fossils
  - dinosaurs
  - extinction theories
- methods of dating

**Environmental Geology**
- geology of Texas
- human responsibilities
- pollution
- conservation

## Meteorology

Meteorology is the study of the gases surrounding the earth. Students study the composition and structure of the atmosphere, its movement in relation to the surface of the planet, and its role in the production of weather and climate. The course could be extended to include the study of the atmospheres of other planets.

Students make observations of the sky, satellite relays, and weather maps and charts. Investigations emphasize accurate observations, collection of data, data analysis, and the safe manipulation of apparatus and materials in the field and laboratory.

## Meteorology (½-1 unit)

| Essential elements | Subelements |
|---|---|
| Meteorology shall be a laboratory-oriented course and shall include the following essential elements: | The student shall be provided opportunities to: |
| (1) Manipulative laboratory skills | demonstrate the safe use of meteorological field/laboratory apparatus |
| (2) The use of skills in acquiring data through the senses | (A) observe meteorological phenomena<br>(B) examine meteorological data |
| (3) The use of classification skills in ordering and sequencing data | classify meteorological conditions according to similarities and differences |
| (4) Experience in oral and written communication of data in appropriate form | (A) describe meteorological conditions and types of weather associated with them<br>(B) describe the factors that influence weather |
| (5) Experience in concepts and skills of measurement using relationships to standards | (A) measure meteorological conditions (temperature, humidity, pressure)<br>(B) place symbols on weather maps<br>(C) plot data on graphs and other displays |
| (6) The use of skills in drawing logical inferences, predicting outcomes, and forming generalized statements | (A) predict the outcome of a meteorological activity from trends in data using inferences, extrapolation, or interpolation<br>(B) formulate a meteorologic hypothesis |
| (7) Experience in skills in relating objects and events to other objects and events | contrast and compare models of meteorological conditions and patterns |
| (8) Experience in applying defined terms based on observations | clarify operational definitions used in explaining meteorological processes |

## Meterology, *continued*

| Essential elements<br>Meterology shall be a laboratory-oriented course and shall include the following essential elements: | Subelements<br>The student shall be provided opportunities to: |
|---|---|
| (9) Experience in identifying and manipulating the conditions of investigations | (A) identify the variables remaining constant, the variables being manipulated, and the variables responding in an investigation in meteorology<br>(B) manage an experimental design to test a meteorologic hypothesis |
| (10) Applications of science in daily life | evaluate the applications and career implications of meteorology principles and the findings of research |

## Suggested Topics for Meteorology

**Definition of Scope of Atmospheric Science**
- time
- space
- matter
- energy
- forces
- motion

**Atmospheric Circulation**
- energy budget
- heating of the earth
- heating of the air
- the rotating earth and the effects rotation has on weather

**Air Masses**
- air mass source regions
- air mass characteristics
- air mass modification

**Cloud Formation and Types**
- evaporation and condensation
- formation of clouds
- classification and characteristics of clouds
- dew points
- precipitation

**Elements of Weather**
- clouds
- temperature
- pressure
- wind
- precipitation
- humidity

**Pressure and Wind**
- barometer
- station pressure
- pressure system characteristics
- pressure gradient
- friction effect
- local wind systems

**Effects of Weather Elements**
- fog
- haze and smoke
- obscured sky conditions
- temperature inversions and stability

**Fronts**
- types and characteristics
- frontal weather

**Storms**
- thunderstorms
- hurricanes
- tornados

**Weather Patterns**
- mountain areas
- lake areas
- desert areas
- ocean shore areas

**Weather Maps**

**Climate**

## Astronomy

Astronomy presents a study of celestial objects in the solar system, the Milky Way, and neighboring galaxies. Emphasis is placed on the earth's motions and its relationship to the remainder of the solar system. Students make observations of celestial objects using the unaided eye, instrumentation, planetaria, and observatories. Models may be used although they should not be substituted for activities using the real sky. Investigations include accurate observations, collection of data, data analysis, and the safe manipulation of apparatus and materials in the field and laboratory.

## Astronomy (½-1 unit)

| Essential elements | Subelements |
|---|---|
| Astronomy shall be a laboratory-oriented course and shall include the following essential elements: | The student shall be provided opportunities to: |
| (1) Manipulative laboratory skills | demonstrate the safe use of astronomical laboratory equipment |
| (2) The use of skills in acquiring data through the senses | (A) observe astronomical objects<br>(B) examine astronomical motions |
| (3) The use of classification skills in ordering and sequencing data | (A) classify astronomical objects according to similarities and differences<br>(B) organize astronomical data into meaningful form |
| (4) Experience in oral and written communication of data in appropriate form | (A) describe astronomical objects<br>(B) describe the theories of the formation of the solar system and the universe |
| (5) Experience in concepts and skills of measurement using relationships to standards | (A) measure astronomical quantities<br>(B) plot data on graphs and other displays |
| (6) The use of skills in drawing logical inferences, predicting outcomes, and forming generalized statements | (A) predict the outcome of an astronomical activity from trends in data using inferences<br>(B) formulate an astronomical hypothesis |
| (7) Experience in skills in relating objects and events to other objects and events | construct and compare models of astronomical objects |
| (8) Experience in applying defined terms based on observations | clarify operational definitions in explaining astronomical cycles and processes |
| (9) Experience in identifying and manipulating the conditions of investigations | (A) identify the variables remaining constant, the variables being manipulated, and the variables responding in an investigation in astronomy<br>(B) identify an experimental design to test an astronomical hypothesis |

## Astronomy, *continued*

| Essential elements | Subelements<br>The student shall be provided opportunities to: |
|---|---|
| Astronomy shall be a laboratory-oriented course and shall include the following essential elements: | |
| (10) Application of science in daily life | (A) analyze the applications and benefits derived from the space program<br>(B) evaluate the applications and career implications of astronomy principles and the findings of research |

### Suggested Topics for Astronomy

**Orbital Motions**
- Newton's laws
- universal gravitation
- Kepler's laws
- escape velocity
- artificial satellites

**Optics and Optical Instruments**
- electromagnetic radiation
- geometrical optics
- spectroscopy
- Doppler effect
- telescopes (reflecting and refracting)
- astrophotography

**Celestial Coordinates and Timekeeping**
- the celestial sphere
- earth's motions
- celestial coordinates
- timekeeping
- seasons
- calendars

**The Earth**
- physical properties
- interior structure
- atmosphere
- estimation of age
- magnetic properties

**The Moon**
- exploration and geology
- physical features
- motions
- phases
- tides
- eclipses (lunar and solar)

**The Other Planets**
- inner and outer planets
- physical features
- interior structures
- atmospheres
- magnetic properties
- motions and configurations
- satellites
- satellite exploration

**Other Objects in the Solar System**
- asteroids
- comets
- meteors

**The Sun**
- physical properties
- motions
- sunspots
- effect on weather
- auroras
- energy production

**Theories of the Formation of the Solar System**

**The Night Sky**
- maps of the sky
- seasonal constellations
- apparent motion of stars
- navigation by stars
- sidereal time

**Tools of the Astronomer**
- telescopes, optical and radio
- spectroscopes
- cameras

**Properties of Stars**
- color
- temperature
- brightness
- size
- spectra

**Measuring Stellar Distances and Brightness**
- parallax
- brightness ratios
- the H-R diagram
- Doppler shift

**Variable Stars and Stellar Groupings**
- binary stars
- eclipsing variables
- pulsating variables
- explosive stars
- star clusters

**Stellar Life Cycles**
- black holes

**Interstellar Matter**
- diffuse nebulae
- planetary nebulae

**Galaxies**
- types
- clusters
- the local group
- Hubble's law

**Quasars**

**Extraordinary Astronomical Events**

**Cosmogony**

## Laboratory Management

Laboratory management is designed to increase student skills in laboratory techniques and procedures. Course enrollment may consist of only one student who acts as laboratory assistant to a science teacher. Only a reliable student who has some aptitude for science should be accepted as a laboratory assistant since it is a position of responsibility. The student assists in setting up equipment, tutoring fellow students, dismantling equipment, organizing supplies, mixing reagent, and bookkeeping. The student should have one unit of credit in the science course in which he or she will be trained to serve as a laboratory assistant.

Laboratory Management may also be an academically rigorous course in which students develop unique, original, and creative approaches to applying analytical techniques; solving problems using their knowledge, abilities, and creativity; and manipulating technological innovations.

## Laboratory Management (½-1 unit)

| Essential elements | Subelements |
|---|---|
| Laboratory Management shall be a laboratory-oriented course and shall include the following essential elements: | The student shall be provided opportunities to: |
| (1) Manipulative laboratory skills | (A) demonstrate the safe use of laboratory chemicals and equipment<br>(B) demonstrate proper investigative laboratory techniques |
| (2) The use of skills in acquiring data through the senses | (A) observe student laboratory activities<br>(B) study safety hazards encountered by students and methods of eliminating the hazards |
| (3) The use of classification skills in ordering and sequencing data | (A) classify student manipulative equipment and supplies according to similarities and differences<br>(B) sequence a student laboratory activity |
| (4) Experience in oral and written communication of data in appropriate form | (A) communicate laboratory and safety directions<br>(B) interpret meaningful arrangements of student data |
| (5) Experience in concepts and skills of measurement using relationships to standards | (A) quantify student laboratory information<br>(B) plot data on graphs and other displays |
| (6) The use of skills in drawing logical inferences, predicting outcomes, and forming generalized statements | (A) predict the outcome of student activities from trends in data<br>(B) formulate a student hypothesis from a laboratory investigation |
| (7) Experience in skills in relating objects and events to other objects and events | compare and contrast student data |

## Laboratory Management, *continued*

| Essential elements | Subelements |
|---|---|
| Laboratory Management shall be a laboratory-oriented course and shall include the following essential elements: | The student shall be provided opportunities to: |
| (8) Experience in applying defined terms based on observations | clarify the operational definitions used in explaining laboratory procedures |
| (9) Experience in identifying and manipulating the conditions of investigations | identify the variables remaining constant, the variables being manipulated, and the variables responding in a laboratory investigation |
| (10) Application of science in daily life | (A) apply skills of laboratory management<br>(B) evaluate the applications and career implications of laboratory management principles and the findings of research |

### Suggested Duties for Laboratory Management

The duties of the laboratory assistant may vary due to the course and the local situation. The emphasis of the duties should be upon laboratory skills that will benefit both the student and the teacher. The grading of tests would not be a proper duty for the student assistant. Listed below are some competencies to be acquired and duties to be performed appropriate for the course.

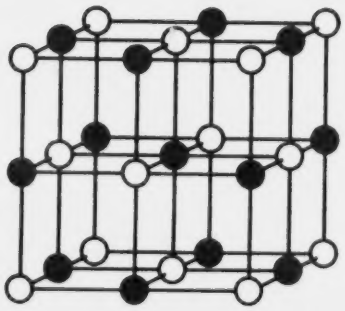
**Acquired Competencies**

knowledge of operating procedures of laboratory equipment
knowledge of safe storage and inventory procedures for laboratory chemicals
knowledge of laboratory safety procedures and emergency first aid
expertise in specific laboratory techniques

**Laboratory Duties**

keeping laboratory equipment in proper place
making sure instruments glassware are clean when stored
demonstrating, with teacher assistance, proper technique to peers
keeping a laboratory inventory
caring for living materials, when appropriate; for example, cleaning and feeding animals, watering plants, keeping cultures and bacteria viable, and keeping drosophilia cultures hardy
mixing reagents and solutions needed for lab activities. (Mixing reagents should always be done under close supervision of the teacher.)
assisting in cleaning the laboratory and its equipment

# Special Student Populations and Science



# Introduction

Students comprising "special populations" include learners with a wide variety of characteristics. Some of these students are from migrant families. Some are gifted and talented. And some are limited in English proficiency. What these students share, despite their differences, is a need for alternative approaches to instruction in the classroom.

Curriculum modifications are strategies for good teaching that would benefit any student. For example, varying the method of instruction, modifying materials, adding personnel to achieve a one-to-one relationship, and changing the pace of presentation are all types of modifications teachers might use to meet individual student needs. To reteach and remediate content or skills to a special education migrant student, or a limited education student, teachers might employ similar strategies—breaking up a unit into smaller, sequential steps. Because the same techniques work for several categories of students, repetition necessarily occurs in the discussion of modifications in the following sections.

Some students need a concentrated effort in one or more modifications specific to their needs. These students may have a handicap, may speak English or a language other than English, may be in difficult economic situations, or may experience language deficiencies in English, the native language or both, or may suffer chronic underachievement. Developing modifications tailored to the specific situation of these students challenges any instructional staff.

Administrators, curriculum supervisors, and classroom teachers may find it helpful to use this chapter, Special Student Populations and Science, as a pool of suggestions of teaching practices widely held to be effective for most students. They may also use specific sections as a reference for suggestions as they identify and serve students with individual needs.

# Goals

A major goal of an education program is to provide all students with appropriate opportunities to grow to the full extent of their abilities. Prior to implementation of Chapter 75, students received remedial instruction which, in many cases, was isolated, fragmented, and unrelated to the regular instructional program. Consequently, some students were unable to maintain steady progress when they returned to the regular program of instruction. The state basic curriculum now requires a process that ensures a well-balanced single curriculum for all students regardless of identified needs or conditions. Students with identified instructional needs vary in academic ability and language proficiency levels. Regardless of their level, all students need to be provided instruction in the same essential elements.

Programs for students with identified needs should be modified in terms of instruction, pacing and materials, as appropriate, to provide full opportunity for these students to learn the essential elements. Programs for special population students may also use specialized personnel. These special program teachers and the regular instructional personnel are responsible for providing a comprehensive program of instruction for those students identified as having particular educational needs.

The science essential elements listed in Chapter 75 for kindergarten through Grade 12 are applicable for all Texas students regardless of their physical limitations, mental abilities, language development, and emotional maturity. The science essential elements cover a wide range of academic challenges from basic, life-sustaining skills to analytical problem solving. They are as follows:

1. **Manipulative laboratory skills (required in kindergarten-Grade 12).** As a psychomotor skill, this essential element promotes manual dexterity, eye-hand coordination, and laboratory techniques specific to the grade or course. Students are given opportunities to manipulate specimens, apparatus, and materials, thus developing their laboratory skills. All students benefit from experiences that allow them to interact with manipulatives. Limited English proficient students are not hampered by their language limitations when allowed to acquire first-hand information and investigate concepts in a hands-on laboratory setting. Students who are working below grade level can perform lab experiences successfully and make conceptual and academic skill gains given the opportunity to interact with concrete manipulatives. Gifted and talented science students can be stimulated to further investigate concepts and can learn to use more advanced and more technical equipment than the average or below average learner. They may also be encouraged to manipulate more complex variables and to develop more elaborate laboratory techniques.
2. **The use of skills in acquiring data through the senses (required in kindergarten-Grade 12).** All students require opportunities to develop their powers of observation through multisensory experiences. Students who do not have access to a curriculum in their primary language or whose reading is below grade level gain information from those objects and events that comprise their environment and are not to be penalized for their lack of language skills. Effective teachers can capitalize on the migrant students' experiences in the outdoors and augment observation skills that are essential and practical to these students. Students with handicaps begin to further develop and use senses unaffected by their handicap while learning to gather new information. Gifted and talented students can further increase their potential to assimilate old information, to create new ideas, to hone their senses, and develop keen observation skills.
3. **The use of classification skills in ordering and sequencing data (required in kindergarten-Grade 12.)** All students notice similarities and differences in objects and events when these skills are taught in concert with observation skills. By manipulating concrete objects while developing their classification skills, students with language limitations are able to progress along with their classmates. Gifted students are able to expand their classification schemes and apply them to self-designed experiments.

4. **Experience in oral and written communication of data in appropriate form (required in kindergarten-Grade 12).** One of the strengths of the science program is that it allows special students to express themselves concretely. When language is a barrier, students are often eager for other opportunities for expression. Science lessons provide these opportunities and allow for spontaneous speech to occur when students are excited about a science discovery. Information is also conveyed using graphs and charts. Teachers should be generous in accepting students' responses and valuing their viewpoints.

5. **Experience in concepts and skills of measurement using relationships to standards (required in Grades 1-12).** The key to measurement is using relationships to standards. Visually handicapped students use their own steps to measure distances. Measurement skills can form a common language for special students and those newly immigrated to the United States. Most foreign students have experienced metric measurement skills, the measurement standard used in science.

6. **The use of skills in drawing logical inferences, predicting outcomes, and forming generalized statements (required in Grades 2-12).** Although this essential element is introduced in Grade 2, younger students are able to predict outcomes. In fact, predictions are survival skills, and all students should have opportunities to predict consequences of unsafe acts. When shown scenarios of overloaded electrical outlets, poor storage of household chemicals, pollutants added to the environment, and mishandling of pets, students of all abilities can form generalized statements varying in sophistication regarding the dangers and efforts to be employed to correct the situations.

7. **Experience in skills in relating objects and events to other objects and events (required in Grades 4-12).** This essential element provides excellent opportunities for remediation, reteaching, and enrichment. The experiences gained in one activity are extended to other activities. Suggestions for extensions are made by the teacher in assessing the need, by the students in expressing a motivation to pursue the topic further, or by the textbook in reinforcing the concept.

8. **Experience in applying defined terms based on observations (required in Grades 4-12).** When they apply defined terms based on observations, students have opportunities to form definitions based on their experiences with the materials. Students do not use the dictionary or a glossary to meet this essential element. Rather, they form definitions with which to express themselves. Students with limited reading skills or with limited use of the English language are encouraged to verbalize the phenomena they witness. After students' initial responses, and not before, the teacher begins to lead their thinking toward more formal methods of expression.

9. **Experience in identifying and manipulating the conditions of investigations (required in Grades 5-12).** All students experience the joy of science when they become involved with the materials. For the identified student whose reading or English language skills are limited, a world of wonder is unfolded. Science is accessible to all students as they manipulate the materials, design investigations, and share their conclusions.

10. **Application of science in daily life (required in Grades 7-12).** Every experience gained in the classroom is made relevant to the larger world. In this way, science becomes part of students' lives. They come to understand the benefits of science, its limitations, and its contributions to technology. Science becomes less "magic" and more applicable.

# Special Education

Science essential elements, required by State Board of Education rule, are basic building blocks for competencies each student must be given the opportunity to develop. Special education students may receive instruction in the essential elements through participation in appropriate options that modify content and methodology to varying degrees. The admission, review, and dismissal (ARD) committee in a school district has the responsibility to develop an individual educational plan (IEP) for each special education student.

Many handicapped students are able to fulfill the science requirements on the same basis as their nonhandicapped peers, or they may use appropriate options such as modified content, methodology, evaluation procedures, personnel, setting, and materials. The IEP developed by the ARD committee is the district's official record of services and instruction needed to ensure the handicapped student an appropriate education. The IEP lists any modifications necessary for satisfactory progress in science, whether the handicapped student is placed in regular or special education classes for instruction. School district procedures direct how the IEP modifications are communicated to the regular and special education personnel responsible for implementation and how evaluation is to take place. Generally, the inability to perform without modification can be attributed to one or more of the following limitations that result from the handicap:

- physical—affects motor coordination
- sensory—affects visual or auditory reception and expression
- cognitive—affects receptive and expressive communication skills
- emotional—affects behavioral and social skills

When the handicapped student is placed in regular classes for science, the teacher can expect to be given specific information about the individual student's skill level and needs. Many handicapped students placed in regular classes experience more difficulty than their nonhandicapped peers with discriminations, comprehension, problem solving, and logical reasoning. When the teacher recognizes the handicapped student's skill level and accommodates instruction accordingly, the student's participation and involvement in the science program provides practice and skill development in other areas as well.

## Modification of Content and Method

While every effort must be made to provide handicapped students instruction in all the essential elements, occasionally, when a handicapping condition renders the content inappropriate for a student, the ARD committee may recommend modification of some essential elements or alternative content. Districts may employ commercially available programs or develop their own to enable handicapped students to attain the goals of the science program insofar as they are able. The hands-on concrete learning experiences outlined by the science essential elements are highly appropriate for special students. Regular and special education teachers may modify course content and the method of delivery in a number of ways. The teacher may:

- clarify course assignments for students
  - repeat instructions; provide more detailed directions
  - provide course syllabus, outline, and objectives
  - use individual contracts with specific requirements
  - give instructions through several channels such as written or oral demonstration
  - summarize key points before starting an assignment
  - provide correctly completed examples

- adapt regular assignments
  - limit the number of variables in the experiment
  - allow more time for or reduce the length of regular assignments
  - break the assignment into a series of smaller assignments, objectives, or skills
  - reduce the reading level of reading assignments by rewording, paraphrasing, and editing. Use high-interest, low-reading level materials to cover the same content covered in the adopted text
  - underline, color code, and outline major points in written assignments
  - change format of instructional materials to include fewer paragraphs, problems, and questions
  - have the student complete activities or problems the teacher starts
  - ask leading, directive questions before the student begins a new assignment
  - allow sufficient "wait-time" and be generous in accepting students' responses
- use alternative materials to supplement the regular text and workbook
- use alternatives to written and reading assignments
  - provide opportunities for oral presentations, reports, and projects done by individuals, small groups, and panels
  - provide instruction through verification, guided inquiry, exploration skill development, and process skill development activities
- provide alternative methods for completing assignments
  - establish a buddy system within the classroom to provide reading and writing assistance and to help in recording and reporting data
  - enlist older students to tutor or provide teacher aide assistance
  - use group assignments to gather data, design experiments, and make conclusions
  - use tape-recorded textbooks and allow students to listen and follow along in the written text; record instructions and assignments
  - provide study questions and word outlines for assignments to assist students in organizing their materials
  - provide the student a spiral notebook word bank which provides a special dictionary for the subject or a notebook of activities including hypotheses, materials, procedures, and results
  - substitute projects for written assignments or reports. Projects may include development of tape recordings, posters, charts, drawings, and illustrations as well as collections of animals, rocks, seeds, and leaves which are appropriate for the science concepts being studied and the students' ability.

## Modification of Assessment

Just as teachers should modify content according to the directions of the ARD committee and the students' needs, they must also select an appropriate form of assessment if the effects of a handicap would invalidate regular testing procedures.

Forms of science assessment requiring extensive reading may cause problems for many handicapped students in regular classes. Often readings are at a higher level than the students can comprehend, and they do not finish the assignment because they spend too much time rereading. Sometimes students are unsure of the importance of what they have read, or they tire and skip important information necessary to complete the assignment accurately.

Nonreading science experiences provided by group projects, collections, audiovisual aids, demonstrations, and field trips give teachers opportunities to assess handicapped students in the science essential elements through active participation. Making models and drawings can also provide opportunities for students to demonstrate mastery without frustrating the students who have reading disabilities.

Testing methods must allow the student to demonstrate knowledge and skills in science regardless of the disability. Appropriate evaluation methods determine achievement without jeopardizing the student for known disabilities. Numerous modifications of exam procedures can be reasonably managed in the regular classroom setting. The teacher may:

- allow open book exams
- allow more time for science labs and paper and pencil tests or reduce the length of these tests
- use multiple choice tests written at the appropriate reading level for the student
- use more objective items and request fewer essay items
- give the same exam orally
- tape record the test or the student's test answers
- reduce the reading level or paraphrase the test; illustrate the test with pictures
- use fill-in responses for word or definition problems
- give take-home tests
- substitute assignments for tests
- allow a peer, teacher aide, or volunteer to administer tests individually
- create a word bank of science terms the student can use during class and as a resource during tests
- design study questions that will help the student organize the material being taught

## Modification of Materials

Adopted textbooks and materials may need to be modified and/or supplemented with other special education instructional materials to teach the essential elements. Visually handicapped and learning disabled students may be provided tape-recorded textbooks and large print or braille materials. The teacher may use alternative materials to supplement the regular text and workbook and may:

- use different formats to teach the same content such as tapes or pictures, the out-of-doors, trips to local stores and industries, and classroom visitors
- borrow, share, or acquire remediation or reinforcement materials from other grades or subject teachers and from the special education materials collections
- use adaptive equipment and facilities
- provide study aids such as hints, cue cards, spelling lists, and guides

## Modification of Personnel and Setting

Special education instruction can reinforce, follow-up, and supplement basic instruction. For example, the special education teacher may provide:

- alternative methods to present the materials to be learned and adaptive methods to assess students' knowledge

- supportive instruction and reinforcement using the same materials as the regular teacher or special instructional materials or media to reinforce concepts presented in the science class
- assistance in determining and demonstrating appropriate behavior in the science classroom
- assistance to the student according to need when engaged at the laboratory station or during field trips

The special education teacher and the science teacher are responsible jointly for teaching the essential elements to the handicapped student in the science classroom unless otherwise stated in the IEP.

# Gifted and Talented Education

Science is an excellent subject in which to differentiate curriculum for gifted students. Because it relies heavily on process skills, it is easy to accelerate the curriculum for the student who readily masters the essential elements. There are, however, other reasons for selecting science as an area of study for gifted students.

Many of Texas' gifted students are bilingual or are going through the transition of learning English. In science, where the use of manipulatives is stressed, bilingual students will not suffer from their lack of language skills. The visual explanation, rather than the verbal explanation that is used in language arts and social studies, assists bilingual gifted students in reaching their full potential in science. School districts that are beginning their planning for a gifted program should keep this in mind if they have a heavy minority population of students.

The basic characteristic of curriculum for gifted students, regardless of content area, is that it is differentiated from the regular curriculum by being accelerated, expanded, or enriched to suit the needs of the gifted learner. This approach is in keeping with the state-mandated guidelines which suggest that districts use these techniques when modifying the curriculum for gifted students.

For example, a Grade 3 science subelement directs students to describe changes that occur in the environment. Students who master this quickly could describe changes that occur in other environments, or they could be accelerated to the Grade 4 subelement that requires them to describe changes in objects over a period of time using terminology such as position, rate, and speed. This simple example shows how the science curriculum can be compacted for the gifted student so that two years of science can be studied in one school year.

Large school districts that have a full range of course offerings for students might well follow this practice. Compacting the curriculum means that students will be ready for higher level science courses when they are in secondary school. Small districts that wish to compact the curriculum may also do so and still provide options for students by taking advantage of several provisions of State Board rule. For instance, administrators from two or more districts may jointly offer a course and may also turn to the regional education service center for assistance. Correspondence courses and high school credit for college courses are two other ways districts may provide for students gifted in science.

In gifted education, students should be exposed to advanced content and sophisticated skills. They should be expected to produce complex products. Certainly the gifted science student would be expected to deal with sophisticated skills such as the use of magnets and balances before Grade 4 when other students are introduced to them. The key with gifted students is not to hold them back but to let them go as far as they can in the science curriculum which is specifically designed to enhance process skill development.

The science process skills may be related to the development of student projects. As an example, in an environmental science class, students observe and examine environmental science principles and expand their understanding of these principles. They investigate logical explanations for the causes and effects of the disappearance of the Kemp's ridley turtle on the Texas coast. Students then develop their projects which might include a conservation campaign based upon their knowledge.

Science is a fascinating subject area to all students, and those who are gifted are no exception. By widening the horizons of what we expect from these students, we will be able to meet the goal of providing each student with development of the personal knowledge, skill, and competence that will help them reach their maximum academic potential.

# Special Programs

## Compensatory Education

Compensatory instruction is targeted for students who are having academic difficulty in science, English language arts, mathematics, reading, and/or social studies. Other students who may require compensatory or remedial instruction include migrant students, students who speak a language other than English, and prekindergarten or kindergarten children who have identified developmental needs.

Compensatory science instruction should extend and reinforce the science program of instruction. Instruction for students in the remedial and compensatory categories should be:

- based on each student's functional instructional level
- designed to teach the science essential elements

There are many reasons why students need special assistance in studying science. Some students may need help with a single concept or skill only, while others may be functioning significantly below the age or grade level of their peers. When it is apparent to the science teacher that a student is not succeeding in the instruction provided, modifications in placement, pacing, and materials should be initiated.

### General Principles of Modification

In providing compensatory education, teachers should:

- identify specific skill needs to ensure that instruction is directed toward specific deficits
- identify specific learning modalities and styles
- identify alternative instructional strategies

### Modification of Pacing and Placement

Teachers are encouraged to:

- assess language proficiency, if necessary, to determine program placement in the appropriate language for instruction
- reinforce reading skills, when appropriate, in which students have been diagnosed as deficient using activities that promote:
  - building science vocabulary based on the students' experiences
  - following directions
  - identifying cause and effect relationships in the laboratory, on campus, and on field trips
  - reading diagrams, graphs, charts, and histograms
  - identifying the main idea
  - making inferences and predictions
  - reading for facts and details
- use small group instruction for laboratory activities
- limit the number of variables in an experiment
- use cross-age tutors, adult tutors, and peer tutors for one-on-one reinforcement and to provide added time on task

- provide athletic coaches, parents, or teachers to serve as mentors
- provide computer-assisted instruction for drill and practice activities, and allow students to use computer simulations and programming for motivation
- provide experiences on the campus grounds and at community resources when appropriate

## Modification of Materials

In modifying materials, teachers may:

- secure multilevel materials that incorporate the essential elements for the unit or course of study
- develop or obtain multimedia materials—kinesthetic, auditory, and visual—to accommodate different learning styles of individual students
- construct study guides for the textbook using an adjusted vocabulary

Special remedial and compensatory alternatives provide assistance in implementation of instructional options. These options include tutorials, special teachers to provide additional time on task, reading improvement courses, locally developed science skills courses, coaching, summer school, and counseling.

The science teacher and any special teacher who provides remedial or compensatory instruction should coordinate instructional activities using a team approach to:

- determine each student's level and identify specific skill needs
- jointly design and implement lesson plans
- adapt or modify instruction based on continuous assessment of student progress

Additional information for students needing compensatory instruction may be found below under Bilingual Education and Migrant Education.

# Bilingual Education

## Science for Students Limited in English Proficiency (LEP)

Administrators should provide a quality science program that involves students with the materials and develops expanded meanings of language, builds vocabulary, and teaches word recognition and comprehension techniques to both LEP and native English-speaking students. English-speaking students in the science classroom acquire prereading and basic reading abilities they can add to the specific requirements a science program demands. Therefore, students proficient in English have a good start in attaining a mental framework upon which to establish the additional competencies needed for successful reading in a science program.

Unfortunately, the LEP student who is struggling to speak, read, and comprehend the English language will have few, if any, of the preskills necessary for academic success in a science program that is based on reading and uses the same instructional methods, materials, and pacing for all students.

Limited English Proficiency (LEP) students have some advantages in the science classroom because the content draws from the physical world with which they are familiar. When LEP students acquire oral and written English through activities that are reinforced by real experiences, experiments, demonstrations, and natural objects, meaning is not communicated by the language alone. For this reason, the science program presents ideal opportunities to LEP students for vocabulary building.

Despite this hands-on orientation, however, the reading requirements of a science program, which may include textbook, workbooks, study sheets, and source documents, are often extensive and unrealistic for some students. The average LEP student who is learning a second language may not, under the ordinary constraints of time, have attained the level of competence necessary for effective reading of these materials. Vocabulary development may still be in an elementary stage, and comprehension of scientific concepts, classifications, and expressions in English, both in spoken and in written context, may still be minimal.

When information is available only through the medium of the second language, students are certain to make little progress and are unlikely to be able to maintain the same instructional pace as their peers. Success in learning science concepts is possible if the LEP student is provided with demonstrations, experiments, visual and oral prompts, and other program modifications.

Two relevant and basic questions should be considered by the teacher responsible for science instruction:

- How much prior skill and knowledge does the student possess?
- How much effective reading is the student able to accomplish in science textbooks written in English?

Answers to these questions will point teachers and administrators to alternatives needed to ensure the academic progress of LEP students. LEP students will also need special help to build:

- word recognition techniques useful for science vocabulary
- competencies in organizing data and information and in sequencing science information and experiments
- proficiencies in problem solving, including posing hypotheses, designing experiments, gathering and analyzing data, and drawing conclusions
- a storehouse of quantitative facts and knowledge
- an awareness of scientific abbreviations
- the ability to follow a set of specific instructions with careful attention paid to each detail

## Modifying the Science Curriculum for LEP Students

Two distinct programs, bilingual education and English as a second language (ESL), may be used as modified approaches to teach science. A bilingual education program makes use of a LEP student's native language as well as English to teach science. An ESL program uses the second language, English, as the medium of instruction along with adaptive methodologies. LEP students' language abilities should be assessed to determine which language should convey the contents of the course. The selection of an appropriate medium to convey content is dependent on the language strengths and maturities of LEP students.

LEP students fall into three basic categories. The first is comprised of those students who understand and speak English with some adequacy but who have not yet learned to read and to write well in English. They will have more success in learning science concepts through oral, kinesthetic, and visual methods. A second type of students understand, speak, and read in their native language but speak no English. They will have more academic success in learning science concepts through kinesthetic experiences and written materials in their native language. A third type of students may speak little English and have only some speaking and no reading skills in their native language. Science concepts should be presented to them through kinesthetic experiences and orally in their native language. Further guidance on the process of determining the students' best language of instruction can be found in the Texas Education Agency publication *Guidelines for Language Usage in Bilingual Education and English as a Second Language Programs,* AD6 320 01.

When a LEP student's language characteristics have been determined, the teacher can identify the appropriate instructional methods, materials, and pacing necessary to ensure mastery of the science essential elements.

## General Principles of Modification

In a bilingual education program, the regular curriculum is provided through dual language use to meet the students' needs. The districts have the responsibility to ensure that instructors modify curriculum according to the learning styles and different needs of various students. The science curriculum that results from a dual language program should:

- foster the critical thinking process
- stimulate continuous reorganization of previously learned ideas
- encourage further investigation of the information presented

## Modification of Methods

The interdisciplinary nature of science experiences provides students with opportunities to apply skills acquired in other content areas while acquiring science skills.

Modifications may need to be made, especially if the activity requires reading or writing. Instructional strategies may include the following objectives:

- to give practice in cause and effect relationships in the environment, laboratory, and on field trips facilitated by providing language and visual cues
- to teach the special vocabulary of the scientist, particularly verbs such as discover, classify, and hypothesize
- to help students build notebooks of their hypotheses, materials, procedures, data, and conclusions of experiments and field experiences
- to ask numerous questions that require higher level thinking responses
- to limit the number of variables in laboratory experiments
- to show the same information through a variety of different charts and visuals
- to stress definitions of terms based on the students' observations
- to read a variety of sources to highlight contributions of scientists, inventors, and researchers

Students' learning can be facilitated in science activities which require reading and writing by using the following instructional objectives:

- to contrast interrogative, negative, and affirmative statements drawn from the science lesson
- to encourage careful, thoughtful reading of short selections in which one main idea is presented
- to encourage students to underline key words or important facts in written student assignments
- to teach interrogative words and expressions and show how they are used in science to answer such questions as who, how, when, and where as well as higher level questions
- to encourage complete sentences, correct spelling, and accuracy of expression of science methods and language

## Modifying the Pacing and Placement

Appropriate pacing may require reordering the sequence in which essential elements are provided until some degree of reading comprehension is reached. Further, secondary LEP students, whose academic program requires fulfillment of graduation credits, will need assistance in pacing course selections to accommodate their language and academic abilities.

Modifications may also involve placing the student at an instructional level determined by what courses the student has successfully completed. Textbooks should be chosen to meet the students' instructional needs. Informal reading inventories in the primary language and in English may be used to determine both instructional level and appropriate textbooks.

### Modifying the Materials

Along with the instructional approaches and pacing modifications noted, modifications of the instructional materials may also be needed for LEP students. For districts with a bilingual education program, state-adopted science textbooks in Spanish are available. Districts may also design appropriate instructional materials in Spanish by incorporating the science essential elements in the content guide. In the ESL programs, the district may use the state-adopted science textbooks adapted to ESL methodologies. Other instructional materials such as teacher-made and commercially made products should be modified according to the students' language and academic abilities. Additional suggestions for modification may include the following:

- to provide a number of pictures to illustrate terms such as names of living things, weather patterns, and parts of the body
- to develop interests and arouse curiosity through hands-on experiences, pictures of the out-of-doors, newspaper clippings, and periodicals
- to use cartoons and leave the balloons above the speakers blank, to be filled in by the students
- to have students prepare glossaries of science vocabularies based on the students' experiences
- to have students prepare collections of science objects such as rocks and leaves
- to prepare difficult passages from textbooks on tape for listening activities
- to support reading instruction in science by having films, records, filmstrips, and other materials which may be used independently or in small groups
- to present clear illustrations and concrete examples to assist the student in understanding complex concepts and skills
- to highlight written materials for readability by enlarging the size of print, by organizing chapters meaningfully, and by writing headings that show introductions for transition from one idea to another

As districts consider modifications, they should remember that the state-adopted texts can provide useful information on selecting materials appropriate for the LEP student.

In sum, these suggestions for modification of the instructional program for teaching science to the LEP student are a beginning. Additional suggestions can be used from the Compensatory, Gifted and Talented, and Migrant Education sections of this framework.

## Migrant Education

While migrant students may be limited in English proficiency, may require compensatory and remedial assistance, or may need enrichment activities to be challenged adequately, the science teacher should be aware of other unique needs they may have. Because of their high mobility, migrant students may receive piecemeal instruction from several schools. The students may attend school part-time, from six to seven months, or they may attend school for the full year. In either situation, migrant students commonly have gaps in their education due to their migratory status.

A useful source from which the teacher may extract vital educational information concerning individual migrant students is the education record of the Migrant Student Record Transfer System (MSRTS). If migrant counselors are available, they can assist the science teachers in planning the instructional program for migrant students. The MSRTS will report credits earned in science courses and partial work completed in this area. Continuity of instruction and the provision of intensive remediation are two crucial ways in which teachers can provide an opportunity for migrant students to learn the essential elements. To provide continuity, school districts can share information through the use of a checklist for elementary students indicating which essential elements have been taught, which ones need to be reinforced, and which ones should be the basis for further instruction.

## General Modification Strategies

The teacher is encouraged to:

- assess the students' instructional levels through informal testing. The readability levels of the text and lab book should be appropriate for the students' skills. Assessment of the students' familiarity with scientific instruments should be considered.
- select and highlight the most important science concepts that help explain and give vocabulary to the essential elements
- prepare brief outlines of units to be studied and highlight important topics in each unit
- prepare prereading and prelaboratory guides to direct students' efforts
- for elementary students, build independent units that can be rearranged as needed to cover areas that have not been taught to the student
- establish a buddy system for recording and reporting data and for completion of assignments
- provide migrant students with oral tests and/or tape-recorded lessons when appropriate
- use a group language experience approach for oral language development when implementing science process skills such as observing, classifying, recording, and reporting data
- allow the students to bring their own culture into the classroom by incorporating it into the content of the course. For example, high school students may bring in sample herbs used for medicinal purposes or further research the use of herbs and plans for healing in different cultures.
- capitalize on students' field experiences. Topics in Life Science such as plants, ecosystems, and environment are relevant to the migrant experience.
- provide opportunities for small-group interactions in laboratory experiences as well as classroom group discussions
- provide mentors for gifted migrant students who show exceptional ability and interest in a certain field
- assign science homework and course projects that are relevant to the migrant student. An elementary student may be asked to record observations on weather conditions and their effect on crops. A high school student could be encouraged to examine soil samples. Gifted migrant students could explore solutions to the problems posed by the use of pesticides. All migrant students would benefit from learning about the effects of pesticides on health.

## Modification of Pacing and Placement

The teacher may:

- allow opportunities for independent work that may be completed through prepared independent units of study
- use tutors to supplement instruction; keep student-teacher, aide, or peer ratio low
- establish extra classes in the evening, on weekends, and during the summer
- provide computer-assisted instruction for remedial and enrichment purposes
- assess facets of the students' migrant experience that may help them to more rapidly grasp and master certain science essential elements. For example, the migrant students' experience with plants may help them distinguish between types of leaves or parts of plants. Secondary students familiar with harvests, in turn, may readily understand the concept of ecosystem or the economic importance of microbes, plants, and animals.

## Modification of Materials

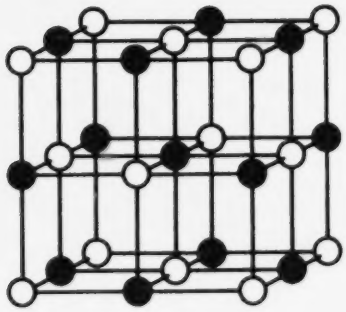
In modifying the materials, the teacher may:

- modify textbook passages to a more appropriate reading level
- make use of high-interest, low-reading level materials

- use tapes, films, oral presentations, demonstrations, experiments, and displays
- develop the students' research skills and problem-solving abilities. Provisions for independent projects that allow students to design experiments relevant to the migrant experience should be encouraged. These could be entered in school science fairs or displayed in school.
- accommodate the learning styles or needs of the migrant student. For example, a poor reader may understand many science concepts via tape, film, and oral presentation. Likewise, demonstration of mastery may be accomplished orally or by building models or experimental designs rather than by written assessment. Active participation using a hands-on approach is vital for mastering difficult and abstract science concepts.

In sum, many migrant students present the district with unique challenges. Are the instructional needs due to lack of experience or background? Do educational needs stem from lack of time on task, or are they truly remedial in nature? Responses to these questions have implications for the district's programming for migrant students. Suggestions in the Compensatory Education, Bilingual Education, and Gifted and Talented Education sections of this framework may also be used to plan an effective instructional program for migrant students. Through careful analysis, the district will be able to provide effective student programs that produce the vital understandings basic to succeeding in the science program.

# Appendices



# Appendix I

## Examples of Alternative Assessment Procedures

Proficiency checklists on pages 130-133 are examples of alternative assessment procedures. They are designed for use within a period of time such as six weeks in which a variety of student activities occur.

Students are assessed according to proficiencies listed, although all proficiencies do not apply to each activity. All students cannot be assessed during a single activity or laboratory period, but assessment can be completed for several students as the teacher moves about the class answering questions.

Checklists should not burden the teacher with additional paperwork. Rather, the teacher divides the time devoted to student evaluation between formal grading practices and informal, observational grading procedures.

# Checklist of Student's Skills Demonstrated During Science Activities

## For School Year 19 -

Grade _____

Student _____

| Subelements | Manipulates laboratory equipment, materials, and procedures in a safe manner | Demonstrates objective observation | Classifies information according to selected criteria | Communicates data orally | Communicates data in written form | Demonstrates skill in measurement | Makes predictions based on observations | Makes inferences based on data | Relates objects and events to other objects and events | Defines terms operationally | Identifies the variables of an investigation | Manipulates the conditions of an investigation |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1A Construct models | | | | | | | | | | | | |
| 1B Use a microscope | | | | | | | | | | | | |
| 2A Observe phenomena of natural cycles | | | | | | | | | | | | |
| 2B Observe results of phenomena associated with electricity | | | | | | | | | | | | |
| 2C Observe effects of phenomena associated with light and sound | | | | | | | | | | | | |
| 3A Classify objects, actions, events by similarities and differences | | | | | | | | | | | | |
| 3B Classify materials as being metallic or nonmetallic | | | | | | | | | | | | |
| 3C Classify human body systems and their functions | | | | | | | | | | | | |
| 4A Describe changes in objects and events | | | | | | | | | | | | |
| 4B Interpret meaningful arrangements of data | | | | | | | | | | | | |
| 5A Collect information by measuring objects and recording data on graphs and tables | | | | | | | | | | | | |
| 5B Measure weather conditions (temperature, wind direction, humidity) | | | | | | | | | | | | |
| 6A Predict outcome from a trend in data | | | | | | | | | | | | |
| 6B Predict cause-and-effect relationships | | | | | | | | | | | | |
| 7A Compare objects according to motion, volume, mass, and speed | | | | | | | | | | | | |
| 7B Relate knowledge and skills of science to careers | | | | | | | | | | | | |
| 7C Compare various ecosystems | | | | | | | | | | | | |

(✓, -)

# Checklist of Student's Skills Demonstrated During Science Activities

**For _____ Six Weeks**

| Student's Name | Manipulates laboratory equipment, materials, and procedures in a safe manner | Demonstrates objective observation | Classifies information according to selected criteria | Communicates data orally | Communicates data in written form | Demonstrates skill in measurement | Makes predictions based on observations | Makes inferences based on data | Relates objects and events to other objects and events | Defines terms operationally | Identifies the variables of an investigation | Manipulates the conditions of an investigation |
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(✓, –)

| Activities<br>Proficiencies | |
|---|---|
| **General** | |
| Demonstrates objective observation | Item:<br>Mastery: |
| Classifies information according to selected criteria | Item:<br>Mastery: |
| Communicates in scientific terms orally and in writing | Item:<br>Mastery: |
| Demonstrates skill in measurement | Item:<br>Mastery: |
| Compares and contrasts scientific objects, processes, and phenomena | Item:<br>Mastery: |
| Defines terms operationally | Item:<br>Mastery: |
| Works well independently and cooperatively | Item:<br>Mastery: |

| Activities<br><br>Proficiencies | |
|---|---|
| **Investigative** | |
| Manipulates laboratory equipment, materials, and procedures in a safe manner | Item:<br><br>Mastery: |
| Formulates scientific hypotheses | Item:<br><br>Mastery: |
| Identifies and manipulates the variables in an investigation | Item:<br><br>Mastery: |
| Makes predictions concerning scientific phenomena | Item:<br><br>Mastery: |
| Makes inferences concerning scientific phenomena | Item:<br><br>Mastery: |
| Generalizes from data or observation | Item:<br><br>Mastery: |
| Designs an experiment to test hypotheses | Item:<br><br>Mastery: |

# Appendix II

## Basic Materials and Equipment Lists

An adequate amount of materials, equipment, and workable space is necessary for laboratory-oriented science. The actual materials and equipment needed will depend upon the activities conducted by the teacher in accordance with the district curriculum. The supplies and equipment should be purchased only after careful scrutiny of the school district's curriculum, selected textbook series, and the teacher's lessons. On pages 136-155 are lists of suggested basic materials and equipment for elementary, life science, earth science, physical science, biology, chemistry, and physics.



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# Minimum Suggested Elementary Science Equipment

*Materials and equipment may be placed on a cart or in an elementary science laboratory center so that teachers can share them.*

| Quantity Needed/Class | Inventory | Recommended Item (General Science) |
|---|---|---|
| 2 | | Funnel |
| | | Many and varied metric measuring devices for volume, length, mass, temperature |
| | | Three-dimensional shapes |
| 1 | | Clock with sweep secondhand |
| | | *Many and varied textures |
| | | Containers—*plastic jars, #beakers, #test tubes, #jars, plastic tube |
| 25 | | Eye droppers |
| | | Lenses—magnifying, concave, convex, biconcave, biconvex |
| 25 | | Mirrors—nonbreakable |
| | | Thermometers—indoor, outdoor |
| 25 | | Metal tongs |
| | | Weights—washers, nuts, metric |
| 1 | | Hammer |
| 1 | | Screwdriver |
| 5 | | Flashlights |
| 100 | | Marbles |
| | | |
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| Quantity Needed/Class | Inventory | Recommended Item (Life Science) |
|---|---|---|
| | | Aquarium—pump, tubing, filter |
| | | Terrarium |
| | | Feathers |
| | | Bones |
| | | Yeast |
| | | *Various food stuffs (for tasting) |
| | | *Various scents |
| | | Models—plants, animals, human body, life cycles, ecosystems |
| 6 | | #Microscopes |
| | | #Light source |
| | | #Slides |
| | | #Stain |
| | | #Preserved specimens (not for dissection purposes) |
| | | Posters—ecosystems, extinct species, endangered species, body systems |
| | | |
| | | **Suggested Living Materials:** |
| | | Elodea |
| | | Guppies |
| | | Fish food |
| | | Snails (land and water) |
| | | Brine shrimp |
| | | Sow bugs |
| | | Mealworms |
| | | Crickets |
| | | Seeds (i.e., beans, corn, radish, grass, clover, rice, squash, etc.) |
| | | Plants |
| | | Gerbils |
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*Specifically for primary science.
#Specifically for intermediate science.

| Quantity Needed | Inventory | Recommended Item (Earth Science) |
|---|---|---|
| | | Aquarium—pump, tubing, filter |
| | | Terrarium |
| 12 | | Compasses |
| | | Rocks |
| | | Soils (sterile) |
| | | Clay |
| | | Mineral |
| | | Sand paper |
| | | Models—globes, lithosphere, hydrosphere, atmosphere, solar system, rock cycles, lunar |
| | | #Weather instruments |
| | | #Metals |
| | | #Nonmetals |
| | | Posters—#geological timetable, land forms, oceans, solar system, astronomy |
| | | |
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| Quantity Needed/Class | Inventory | Recommended Item (Physical Science) |
|---|---|---|
| | | Acetate film of various colors |
| 1 | | Hot plate |
| | | Six simple machines |
| | | Metal file |
| | | Iron filings |
| | | Iron nails |
| | | Magnets—bar, horseshoe, round |
| | | Objects attracted to magnets |
| | | Objects not attracted to magnets |
| | | Batteries—6 volt, size C, solar cells |
| | | Wires |
| | | Sockets |
| | | Light bulbs |
| | | Circuit boards |
| | | *Boxes to be pushed and pulled |
| | | Crystals |
| | | Prisms |
| | | Lenses—concave, convex, biconcave, biconvex |
| | | Tuning forks |
| | | Posters—periodic chart (lecture size and student size) |
| | | Compasses |
| | | Various noise making devices |
| | | #Voltmeter |
| | | Models—pendulum, #electrical devices |
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*Specifically for primary science.
#Specifically for intermediate science.



51.1

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| Quantity Needed | Inventory | Recommended Item (Consumables) |
|---|---|---|
| | | Baking soda |
| | | Food coloring |
| | | Salt |
| | | #Vinegar |
| | | Detergent |
| | | Diluted iodine solution |
| | | Oil |
| | | Alcohol |
| | | Corn Starch |
| | | Paper (graph, construction, wax) |
| | | Paper cups |
| | | Aluminum foil |
| | | Plastic spoons |
| | | Straws |
| | | Cellophane bags |
| | | Twist ties |
| | | Plastic wrap |
| | | String and fishing line |
| 4 packages | | Balloons |
| 5 packages | | Modeling clay |
| 2 rolls | | Masking tape |
| 1 box | | Brass fasteners |
| 2 boxes | | Colored pencils |
| 1 box | | Rubber bands |
| 2 packages | | Pipe cleaners |
| 1 box | | Cover slips |
| | | Fertilizer |
| 10 | | Batteries |
| 10 | | Flashlight bulbs |
| | | Insulated copper wire |
| | | Thumb tacks |
| | | Paper clips |
| | | Plaster of Paris |
| | | Feathers |
| | | Bones |
| | | Yeast |
| | | *Various food stuffs (for tasting) |
| | | *Various scents |
| | | Candles |
| | | Marbles |
| | | Toothpicks |
| | | #Acid/base indicators |
| | | #Hydrogen peroxide |
| | | #Ammonia |
| | | #Bleach |

*Specifically for primary science.
#Specifically for intermediate science.

# Science Equipment
## Life Science (Grades 7-8)

| Quantity Needed/School | Inventory | Recommended Items |
|---|---|---|
| | | **General Items** |
| 24 | | Balances (triple beam or double pan) |
| 36 | | Beakers, Pyrex—100 ml |
| 72 | | Beakers, Pyrex—250 ml |
| 36 | | Beakers, Pyrex—600 ml |
| 4 | | Beakers, Pyrex—1000 ml |
| 2 | | Beakers, Pyrex—2000 ml |
| 72 | | Bottles, dropping |
| 18 | | Bottles, plastic wash |
| 6 | | Brushes, beaker |
| 1/classroom | | Chart, metric |
| 1 | | Cork borer set and sharpener |
| 12 | | Extension cords, heavy duty |
| 36 | | Flasks, Erlenmeyer—250 ml |
| 2 | | Flasks, Erlenmeyer—1000 ml |
| 1 | | Flasks, Erlenmeyer—2000 ml |
| 12 | | Funnels, short stem, plastic |
| 24 | | Graduated cylinders—10 ml |
| 24 | | Graduated cylinders—100 ml |
| 1 | | Graduated cylinders—1000 ml |
| 10 | | Hot plates |
| 1 | | Laboratory cart |
| 1 gross | | Medicine droppers |
| 4 | | Meter sticks |
| 1 classroom set | | Metric rulers |
| 12 | | Rods, glass stirring |
| 12 | | Spatulas |
| Gross | | Stoppers, rubber and cork, assorted |
| 1 | | Stopwatch |
| 24 | | Test tube holders |
| 12 | | Test tube racks |
| 72 | | Test tubes, 15 x 125 |
| 72 | | Test tubes, 20 x 150 |
| 24 | | Thermometers, metal-backed, alcohol, calibrated |
| 12 | | Tongs, beaker |
| 12 | | Tongs, laboratory |
| 1 | | Tool kit which includes: hammer, pliers, set of Allen wrenches, |
| | | screw driver set, soldering iron, wire cutters |
| 12 | | Watch glasses |
| 1/classroom | | Fire extinguisher |
| 1/preparation room | | Fire extinguisher |
| 1/classroom | | First-aid kit |
| 1 classroom set | | Safety goggles |
| 1/classroom | | Safety goggle sanitizer |
| 1 classroom set | | Laboratory aprons |

# Science Equipment

## Life Science (Grades 7-8), *continued*

| Quantity Needed/School | Inventory | Recommended Items |
|---|---|---|
| | | **General Items, *continued*** |
| 1/classroom | | Fire blanket |
| 1/classroom | | Eyewash |
| | | |
| | | **Specific Items** |
| 2 | | Aquaria (10 gallon) |
| | | Aquaria supplies |
| 2 | | fish nets |
| 2 | | filters |
| 2 | | pumps |
| 2 | | heaters |
| 2 | | light sources |
| 1 | | Insect net |
| 1 box | | Insect pins |
| 12 | | Microscopes, regular, student |
| 1 | | Microscopes, stero |
| 1 | | Model, cell |
| 1 | | Model, ear |
| 1 | | Model, eye |
| 1 | | Model, flower |
| 1 | | Model, frog |
| 1 | | Model, heart |
| 1 | | Model, human torso |
| 1 | | Model, lung demonstration |
| 1 | | Model, mitosis/meiosis |
| 12 | | Petri dishes |
| 1 gross | | Microscope slides |
| 1 | | Stethoscope |
| 12 | | Streak plates |
| 12 | | Thermometers, oral with disposable covers |
| | | Planting supplies, pots, soil, tools |
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# Science Equipment
## Earth Science (Grades 7-8)

| Quantity Needed/School | Inventory | Recommended Items |
|---|---|---|
| | | General Items |
| 24 | | Balances (triple beam or double pan) |
| 36 | | Beakers, Pyrex—100 ml |
| 72 | | Beakers, Pyrex—250 ml |
| 36 | | Beakers, Pyrex—600 ml |
| 4 | | Beakers, Pyrex—1000 ml |
| 2 | | Beakers, Pyrex—2000 ml |
| 72 | | Bottles, dropping |
| 18 | | Bottles, plastic wash |
| 6 | | Brushes, beaker |
| 1/classroom | | Chart, metric |
| 1 | | Cork borer set and sharpener |
| 12 | | Extension cords, heavy duty |
| 36 | | Flasks, Erlenmeyer—250 ml |
| 2 | | Flasks, Erlenmeyer—1000 ml |
| 1 | | Flasks, Erlenmeyer—2000 ml |
| 12 | | Funnels, short stem, plastic |
| 24 | | Graduated cylinders—10 ml |
| 24 | | Graduated cylinders—100 ml |
| 1 | | Graduated cylinders—1000 ml |
| 10 | | Hot plates |
| 1 | | Laboratory cart |
| 1 gross | | Medicine droppers |
| 4 | | Meter sticks |
| 1 classroom set | | Metric rulers |
| 12 | | Rods, glass stirring |
| 12 | | Spatulas |
| Gross | | Stoppers, rubber and cork, assorted |
| 1 | | Stopwatch |
| 24 | | Test tube holders |
| 12 | | Test tube racks |
| 72 | | Test tubes, 15 × 125 |
| 72 | | Test tubes, 20 × 150 |
| 24 | | Thermometers, metal-backed, alcohol, calibrated |
| 12 | | Tongs, beaker |
| 12 | | Tongs, laboratory |
| 1 | | Tool kit which includes: hammer, pliers, set of Allen wrenches, |
| | | screw driver set, soldering iron, wire cutters |
| 12 | | Watch glasses |
| 1/classroom | | Fire extinguisher |
| 1/preparation room | | Fire extinguisher |
| 1/classroom | | First-aid kit |
| 1 classroom set | | Safety goggles |
| 1/classroom | | Safety goggle sanitizer |
| 1 classroom set | | Laboratory aprons |

# Science Equipment

## Earth Science (Grades 7-8), *continued*

| Quantity Needed/School | Inventory | Recommended Items |
|---|---|---|
| | | **General Items, *continued*** |
| 1/classroom | | Fire blanket |
| 1/classroom | | Eyewash |
| | | |
| | | **Specific Items** |
| 1 | | Anemometer |
| 1 | | Aneroid barometer |
| | | Charts |
| 1/classroom | | periodic |
| 1/classroom | | star |
| 1 | | Cloud chamber |
| 36 | | Compass, magnetic |
| 6 | | Hammer, rock |
| 1 | | Hygrometer |
| 1/student | | Magnifying lenses, hand |
| 1 | | Mineral set, labeled |
| 1 | | Model, celestial globe |
| 1 | | Model, world globe |
| 1 | | Model, land form |
| 1 | | Model, planetarium |
| 1 | | Radiometer |
| 1 | | Rain gauge |
| 2 | | Rock set, labeled |
| 1 | | Soil sampling tube |
| 1 | | Weather map, markable |
| 1 | | Wind vane |
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# Science Equipment
## Physical Science (Grades 9-10)

| Quantity Needed/School | Inventory | Recommended Items |
|---|---|---|
| | | General Items |
| 24 | | Balances (triple beam or double pan) |
| 36 | | Beakers, Pyrex—100 ml |
| 72 | | Beakers, Pyrex—250 ml |
| 36 | | Beakers, Pyrex—600 ml |
| 4 | | Beakers, Pyrex—1000 ml |
| 2 | | Beakers, Pyrex—2000 ml |
| 72 | | Bottles, dropping |
| 18 | | Bottles, plastic wash |
| 6 | | Brushes, beaker |
| 1/classroom | | Chart, metric |
| 1 | | Cork borer set and sharpener |
| 12 | | Extension cords, heavy duty |
| 36 | | Flasks, Erlenmeyer—250 ml |
| 2 | | Flasks, Erlenmeyer—1000 ml |
| 1 | | Flasks, Erlenmeyer—2000 ml |
| 12 | | Funnels, short stem, plastic |
| 24 | | Graduated cylinders—10 ml |
| 24 | | Graduated cylinders—100 ml |
| 1 | | Graduated cylinders—1000 ml |
| 10 | | Hot plates |
| 1 | | Laboratory cart |
| 1 gross | | Medicine droppers |
| 4 | | Meter sticks |
| 1 classroom set | | Metric rulers |
| 12 | | Rods, glass stirring |
| 12 | | Spatulas |
| Gross | | Stoppers, rubber and cork, assorted |
| 1 | | Stopwatch |
| 24 | | Test tube holders |
| 12 | | Test tube racks |
| 72 | | Test tubes, 15 × 125 |
| 72 | | Test tubes, 20 × 150 |
| 24 | | Thermometers, metal-backed, alcohol, calibrated |
| 12 | | Tongs, beaker |
| 12 | | Tongs, laboratory |
| 1 | | Tool kit which includes: hammer, pliers, set of Allen wrenches, |
| | | screw driver set, soldering iron, wire cutters |
| 12 | | Watch glasses |
| 1/classroom | | Fire extinguisher |
| 1/preparation room | | Fire extinguisher |
| 1/classroom | | First-aid kit |
| 1 classroom set | | Safety goggles |
| 1/classroom | | Safety goggle sanitizer |
| 1 classroom set | | Laboratory aprons |

## Physical Science (Grades 9-10), *continued*

| Quantity Needed/School | Inventory | Recommended Items |
|---|---|---|
| | | **General Items, *continued*** |
| 1/classroom | | Fire blanket |
| 1/classroom | | Eyewash |
| | | |
| | | **Specific Items** |
| 1 | | Ammeter |
| 24 | | Balances, spring, 250g |
| 36 | | Balls, steel, 1 inch |
| 6 | | Brushes, pipette, small |
| 12 | | Brushes, test tube, regular |
| 24 | | Burners, Bunsen with hoses and wingtips |
| 10 | | Carriages, Hall's |
| 1/classroom | | Charts, periodic |
| 24 | | Clamps, Hoffman |
| 72 | | Clips, alligator with wire |
| 36 | | Compass, magnetic |
| 1 | | Conductivity indicators |
| 1 | | Convection box |
| 10 | | Electroscope |
| 12 | | Flashlights |
| 1 | | Friction block set |
| 1 | | Friction plates |
| 1 set | | Friction rods (hard rubber and glass) |
| 1 | | Geiger counter with speaker |
| 1 | | Hydrometer |
| 10 | | Light sources with bulb |
| 10 pair | | Magnets, bar, flat |
| 1 | | Magnets, horse shoe |
| 1 | | Mirror, concave |
| 1 | | Mirror, convex |
| 12 | | Mirror, plane |
| 1 | | Mortar and pestle |
| 12 | | Overflow can with 6 rectangle solid sets |
| 1 | | Power supply, DC with 16 pairs of leads |
| 1 | | Prism, glass, equilateral |
| 12 | | Pulley, single sheave—6 double and 6 triple |
| 1 | | Radiometer |
| 24 | | Ring stand with 4" rings |
| 1 | | Slinky or wave spring |
| 1 | | Solar cell |
| 12 | | Spectroscope or diffraction gradients |
| 12 | | Switch, knife, electrical |
| 12 | | Thermometers, mercury, Celsius |
| 1 | | Transformer, AC, 115V-10V |
| 12 | | Triangular files |

# Science Equipment

## Physical Science (Grades 9-10), *continued*

| Quantity Needed/School | Inventory | Recommended Items |
|---|---|---|
| | | **Specific Items, *continued*** |
| 1 set | | Tuning forks, assorted frequencies |
| 1 | | Ultra violet light source |
| 2 | | Wire flame tester, nichrome or chromel |
| 24 | | Wire screens, ceramic-centered |
| 1 roll | | Wire, copper |
| 1 | | Voltmeter |
| 15 classroom | | Batteries, bulbs, sockets |
| 10 | | Electric motors, small (kits) |
| 2 rolls/classroom | | Tape, electrical and masking |
| | | |
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# Science Equipment
## Biology

| Quantity Needed | Inventory | Recommended Items |
|---|---|---|
| 1/classroom | | Aquarium—10 or 20 gallons with accessories |
| 1/classroom | | Autoclave + 2 pairs heat resistant gloves |
| 3/classroom | | Balance, 0.1g—triple beam, single pan |
| 5/school | | Battery jars, large—1 gallon |
| 4/classroom | | Beaker brushes |
| 24/classroom | | Beakers, Griffin or Pyrex—100 ml |
| 24/classroom | | Beakers, Griffin or Pyrex—250 ml |
| 24/classroom | | Beakers, Griffin or Pyrex—600 ml |
| 12/classroom | | Beakers, Griffin or Pyrex—1000 ml |
| 2/school | | Beakers, Griffin or Pyrex—2000 ml |
| 1 gross/school | | Dropping bottles, 10 ml |
| 12/school | | Brushes, camel's hair |
| 15/classroom | | Bunsen burners |
| 1/classroom | | Chart—human anatomy |
| 6/classroom | | Clamp, pinch |
| 2 sets/school | | Cork borer |
| 1/school | | Cork borer sharpener |
| 12/classroom | | Culture dishes |
| 1 roll/school | | Dialysis tubing |
| 5/classroom | | Etherizers |
| 100/classroom | | Fermentation tubes, 100 x 13 mm |
| 4/classroom | | Files, triangular, 4" |
| 10/classroom | | Flask brushes |
| 12/classroom | | Flask, Erlenmeyer—125 ml |
| 24/classroom | | Flask, Erlenmeyer—250 ml |
| 6/classroom | | Flask, Erlenmeyer—500 ml |
| 10/classroom | | Flask, Erlenmeyer—1000 ml |
| | | Flower pots or seed flats |
| 20/classroom | | Forceps, student grade |
| 6/classroom | | Funnels, plastic 4" |
| 18/classroom | | Glass rods, stirring |
| 2 boxes/classroom | | Glass slide cover slips |
| 2 gross/classroom | | Glass slides—regular microscope |
| 15/classroom | | Glass slides—single depression |
| 24/classroom | | Graduated cylinders—10 ml |
| 15/classroom | | Graduated cylinders—100 ml |
| 1/classroom | | Graduated cylinders—500 ml |
| 15/classroom | | Hand lens |
| 4/classroom | | Hot plate, single unit |
| 1/school | | Incubators—70 egg unit |
| 15/classroom | | Inoculating loops |
| 6/school | | Insect nets |
| 1/school | | Laboratory cart |
| 6/classroom | | Lamps, gooseneck |
| 72/classroom | | Medicine droppers |

## Biology, *continued*

| Quantity Needed | Inventory | Recommended Items |
|---|---|---|
| 6/classroom | | Meter sticks |
| 15/classroom | | Microscopes—monocular |
| 2/classroom | | Microscopes—stero-illuminated -dissecting |
| 1/classroom | | Mitosis and Meiosis models |
| 5/classroom | | Mortar and pestle |
| 15/classroom | | Pipet—1 ml graduated |
| 15/classroom | | Pipet—5 ml graduated |
| 15/classroom | | Pipet—10 ml graduated |
| 8/classroom | | Planter flats |
| 1/classroom | | Plant mobile, 3-tiered or greenhouse |
| 15/classroom | | Ring stands with 3" and 4" rings |
| 24/classroom | | Rulers, metric, clear |
| 15/classroom | | Scalpels (replaceable blades) |
| 18/classroom | | Scissors, student, dissecting |
| | | Slides, prepared—microscope or projector |
| 5/classroom | | Spatulas, stainless steel, 4" blade |
| 2 pounds/classroom | | Stoppers, rubber—#5, solid |
| 2 pounds/classroom | | Stoppers, rubber—#6, solid |
| 4 pounds/classroom | | Stoppers, rubber—#6, 1-hole |
| 2 pounds/classroom | | Stoppers, rubber—#6, 2-hole |
| 2 pounds/classroom | | Stoppers, rubber—#7, 2-hole |
| 1/school | | Survey collection—1 of plants, 1 of animals |
| 1/classroom | | Terrarium |
| 3/classroom | | Test tube basket |
| 15/classroom | | Test tube holders |
| 15/classroom | | Test tube racks, 10 place |
| 15/classroom | | Test tube brushes, tufted—regular |
| 15/classroom | | Test tube brushes, tufted—small |
| 72/classroom | | Test tubes—20 x 150 mm |
| 15/classroom | | Test tubes—15 x 250 mm |
| 12/classroom | | Test tubes—25 x 200 mm with screw caps |
| 144/classroom | | Test tubes—10 x 75 mm |
| 15/classroom | | Thermometer 10°C to 110°C, mercury |
| 10/school | | Thermometer, oral |
| 3/classroom | | Tongs, beaker |
| 6/school | | Vacuum bottles |
| 2/school | | Volumeters |
| | | |
| | | **Microbiology** |
| 2/classroom | | Ceramic mats |
| 1/school | | Charts—microbiology |
| 6/classroom | | Culture tubes, plastic cap |
| 1/school | | Incubating oven |
| 1/classroom | | Magnetic stirrer |
| 1/classroom | | Microscopes, oil—immersion |



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# Science Equipment

## Biology, *continued*

| Quantity Needed | Inventory | Recommended Items |
|---|---|---|
| | | **Heredity and Embryology** |
| 1 gross/school | | Culture vial tubes, 25 x 200 mm |
| 15/school | | Dissecting scissors |
| | | |
| | | **Marine Biology** |
| 3/school | | Aquarium—10 or 20 gallons |
| 1/school | | Aquarium—30 gallons |
| 1/school | | Survey set, marine plants and animals |
| 1/school | | Ultra violet filter |
| | | |
| | | **Comparative Anatomy** |
| 15/school | | Dissecting boards |
| 15/school | | Dissecting kits, advanced |
| | | |
| | | **Human Anatomy and Physiology** |
| 1/school | | Bone skull—model |
| 1/school | | Ear—model |
| 1/school | | Eye—model |
| 1/school | | Heart—model |
| 1 school | | Human torso—model |
| 1/school | | Kymograph |
| 1/school | | Micro slide set |
| 1/school | | Physiology kit |
| 1/school | | Rh blood typing unit |
| 4/school | | Sphygmomanometer |
| 4/school | | Stethoscopes |
| 100/school | | Petri dishes 10 x 25 |
| | | |
| | | **Living Materials—Plants** |
| | | |
| | | **Living Materials—Animals** |
| | | |
| | | **Safety Equipment** |
| 24/classroom | | Laboratory aprons |
| 24/classroom | | Safety goggles—chemical |
| 1/classroom | | Safety goggle sanitizer—U.V. |
| 1/classroom | | Eyewash |
| 1/classroom | | Fire extinguisher |
| 1/classroom | | Fire blanket |
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# Science Equipment
## Chemistry

| Quantity Needed | Inventory | Recommended Items |
|---|---|---|
| | | Glassware |
| 1 gross/classroom | | Beakers, Pyrex—100 ml |
| 48/classroom | | Beakers, Pyrex—250 ml |
| 24/classroom | | Beakers, Pyrex—400 ml |
| 24/classroom | | Beakers, Pyrex—600 ml |
| 24/classroom | | Beakers, Pyrex—800 ml |
| 24/classroom | | Beakers, Pyrex—1000 ml |
| 24/classroom | | Burets, Mohr. 50 ml |
| 30/classroom | | Crucible, #0, Coors |
| 30/classroom | | Crucible cover, "F," Coors |
| 72/classroom | | Droppers, medicine |
| 30/classroom | | Droppers, pipet |
| 1 gross/classroom | | Dropping bottles—10 ml |
| 1 gross/classroom | | Dropping bottles—30 ml |
| 15/classroom | | Evaporating dish, 77 mm, Kimax |
| 24/classroom | | Flasks, Erlenmeyer—100 ml |
| 24/classroom | | Flasks, Erlenmeyer—250 ml |
| 24/classroom | | Flasks, Erlenmeyer—500 ml |
| 24/classroom | | Flasks, Erlenmeyer—1000 ml |
| 6/classroom | | Flasks, Erlenmeyer—2000 ml |
| 24/classroom | | Funnels, long stem, 65 mm diameter, glass |
| 24/classroom | | Funnels, short stem, 65 mm diameter, glass |
| 48/classroom | | Glass stirring rods |
| 30/classroom | | Graduated cylinders—10 ml |
| 30/classroom | | Graduated cylinders—50 ml |
| 30/classroom | | Graduated cylinders—100 ml |
| 2/classroom | | Graduated cylinders—500 ml |
| 2/classroom | | Graduated cylinders—1000 ml |
| 10/classroom | | Hydrometer, cylinder, 100 ml |
| 12/classroom | | Mortar and pestle, #1, Coors |
| 24/classroom | | Pipets, glass, 1 ml |
| 24/classroom | | Pipets, glass, 5 ml graduated |
| 24/classroom | | Pipets, glass, 10 ml graduated |
| 180/classroom | | Test tubes—13 × 100 mm |
| 180/classroom | | Test tubes—18 × 150 mm |
| 60/classroom | | Test tubes—25 × 200 mm |
| 1 bundle/classroom | | Tubing, glass, standard assorted wall bundle |
| 36/classroom | | Vial, flat bottom, plastic, 15 × 45 mm |
| 2/classroom | | Volumetric Flasks, 50 ml |
| 4/classroom | | Volumetric Flasks, 100 ml |
| 4/classroom | | Volumetric Flasks, 500 ml |
| 2/classroom | | Volumetric Flasks, 1000 ml |
| 36/classroom | | Watch glass, 75 mm |
| | | |
| | | |

## Chemistry, *continued*

| Quantity Needed | Inventory | Recommended Items |
|---|---|---|
| | | **Hardware** |
| 8/classroom | | Balance—triple beam, .01g |
| 1/classroom | | Barometer, aneroid, dial |
| 24/classroom | | Bunsen burners |
| 2/school | | Centrifuge |
| 1/school | | DC source, 0-12 v, 5 amps |
| 2/school | | Desiccator |
| 1/school | | Distillation apparatus |
| 2/school | | Drying oven |
| 2/school | | Electrolysis apparatus |
| 1/school | | pH meter |
| 1/school | | Spectrophotometer |
| 15/classroom | | Spectroscope |
| 1 of each/school | | Spectrum tubes—Ar, He, Kr, H, Hg |
| 15/school | | Pneumatic trough |
| | | |
| | | **Miscellaneous** |
| 24/classroom | | Brush, beaker |
| 24/classroom | | Brush, buret |
| 24/classroom | | Brush, pipet |
| 24/classroom | | Brush, test tube, assorted |
| 12/classroom | | Clamps, buret, double |
| 48/classroom | | Clamps, utility |
| 24/classroom | | Clamps, pinch |
| 1/classroom | | Charts—common ions |
| 1/classroom | | Chart—periodic |
| 1/classroom | | Chart—spectrum |
| 1/classroom | | Chart—oxidation-reduction potential |
| 24/classroom | | Deflagration spoon |
| 24/classroom | | File, triangular |
| 1 box each/classroom | | Paper, filter, assorted sizes |
| 1 box/classroom | | Paper, chromatography |
| | | Paper, pH |
| 24/classroom | | Ruler, metric, plastic |
| 30/classroom | | Ringstand, 20" |
| 15/classroom | | Ring support with clamp—2" |
| 15/classroom | | Ring support with clamp—4" |
| 15/classroom | | Test tube holder |
| 15/classroom | | Test tube rack, 12 holes |
| 30/classroom | | Thermometers—20°C to 150°C |
| 24/classroom | | Tongs, beaker |
| 24/classroom | | Tongs, crucible |
| 30/classroom | | Triangle, 1½", clay-covered |
| 100 feet/school | | Tubing, rubber, ¼" ID |
| 30/classroom | | Spatula |

## Chemistry, *continued*

| Quantity Needed | Inventory | Recommended Items |
|---|---|---|
| 1 pound/classroom | | Stoppers, rubber—solid #0, 6, 9 |
| 1 pound/classroom | | Stoppers, rubber—#00, 1-hole |
| 1 pound/classroom | | Stoppers, rubber—#0, 1-hole |
| 1 pound/classroom | | Stoppers, rubber—#6, 2-hole |
| 24/classroom | | Wash bottles, plastic |
| 24/classroom | | Wing tip, flame spreader |
| 1 roll/classroom | | Wire, copper, chromel |
| 24/classroom | | Wire gauze 5 x 5, ceramic center |
| | | |
| | | **Safety Equipment** |
| 24/classroom | | Aprons, rubber |
| 1/classroom | | Eyewash |
| 1/classroom | | Fire blanket |
| 1/classroom | | Fire extinguisher |
| 1/classroom | | First-aid kit |
| 24/classroom | | Goggles, chemical |
| 1/classroom | | Goggle sanitizing unit, U.V. |
| 1/school | | Lockable, vented, chemical storage |
| 1/classroom | | Safety shower |

# Science Equipment
## Physics

| Quantity/4 Students | Inventory | Recommended Items |
|---|---|---|
| 1 | | Balance, double pan or triple beam |
| 2 | | Beaker, Pyrex—250 ml |
| 2 | | Beaker, Pyrex—600 ml |
| 1 | | Calorimeter |
| 2 | | Thermometers (Celsius) |
| 1 | | Centripetal force setup |
| 2 | | Support rods, stands, and appropriate clamps |
| 1 | | Heat source (hot plate or bunsen burner) |
| 1/classroom | | Electrostatic demonstration materials |
| 1 | | Diffraction grating |
| 1/classroom | | Gas spectrum tubes (assortment—3 minimum) |
| 1/classroom | | Gas spectrum tube power supply |
| 1/classroom | | Glass plate, interference flat |
| 1/classroom | | Coiled spring |
| 1 | | Hookes Law apparatus |
| 1 | | Index of refraction plate |
| 1/classroom | | Magnetism demonstration materials |
| 1/classroom | | Galvanometer |
| 1 | | Ammeter, DC, student |
| 1 | | Voltmeter, DC, student |
| 1 | | Meter stick |
| 1/classroom | | Motor, St. Louis |
| | | |
| | | Optical Bench Accessories |
| 1 | | Meter stick bench or better |
| 1 | | Lens and mirror support |
| 1 | | Screen |
| 1 | | Screen support |
| 1 | | Light source |
| 1 | | Double convex lens (set of 3 different focal lengths) |
| 1/classroom | | Set of demonstration lenses (concave, convex, etc.) |
| 1 | | Concave mirror |
| 1 | | Convex mirror |
| | | |
| 1/classroom | | Dynamics carts |
| 1/classroom | | Polarization demonstration material |
| 1 | | Low voltage DC power supply, variable |
| 1/classroom | | Power supply, autotransformer, AC |
| 1/classroom | | Set of pulleys (single sheave, double tandem, mountable) |
| 1 | | Recorder timer (pesc type) or 1 precision spark gap timer |
| 1 | | Refraction prism |
| 1 | | Resonance tube |
| 1/classroom | | Wave demonstration materials |
| 1 | | Specific heat specimens |
| 1/classroom | | Spring scales |

# Science Equipment

## Physics, *continued*

| Quantity/4 Students | Inventory | Recommended Items |
|---|---|---|
| 1 | | Force table |
| 1 | | Stop clock |
| 1/classroom | | Stroboscope, adjustable |
| 1/school | | Tape measure (metric and English) |
| 1/classroom | | Tuning forks (set of 3 assorted) |
| 1 | | Vernier caliper |
| 2 | | Weight hanger 50 g |
| 1 | | Slotted weight set (1 g to 500 g) |
| 1/classroom | | Absolute zero demonstrator |
| 1/classroom | | Air table and accessories |
| 1/classroom | | Vacuum system with bell jar |
| 1/classroom | | Brownian motion apparatus |
| 1/classroom | | Spectrum chart |
| 1/classroom | | Periodic chart |
| 1/classroom | | Laser chart |
| 1/classroom | | Demonstration barometer |
| 1/classroom | | Michelson interferometer |
| 1/classroom | | Oscilloscope |
| 1/classroom | | Platform, rotating, heavy duty |
| 1/classroom | | Sine and square wave generator |
| 1/classroom | | Van de Graff generator |
| 1 set/classroom | | Hand tools (pliers, screwdrivers, hammer, soldering iron) |
| 2 sets/classroom | | Wire, assorted sizes |
| 4 sets/classroom | | Test leads with alligator clips |
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## COMPLIANCE STATEMENT

### TITLE VI, CIVIL RIGHTS ACT OF 1964; THE MODIFIED COURT ORDER, CIVIL ACTION 5281, FEDERAL DISTRICT COURT, EASTERN DISTRICT OF TEXAS, TYLER DIVISION

Reviews of local education agencies pertaining to compliance with Title VI Civil Rights Act of 1964 and with specific requirements of the Modified Court Order, Civil Action No. 5281, Federal District Court, Eastern District of Texas, Tyler Division are conducted periodically by staff representatives of the Texas Education Agency. These reviews cover at least the following policies and practices:

(1) acceptance policies on student transfers from other school districts;

(2) operation of school bus routes or runs on a non-segregated basis;

(3) nondiscrimination in extracurricular activities and the use of school facilities;

(4) nondiscriminatory practices in the hiring, assigning, promoting, paying, demoting, reassigning, or dismissing of faculty and staff members who work with children;

(5) enrollment and assignment of students without discrimination on the basis of race, color, or national origin;

(6) nondiscriminatory practices relating to the use of a student's first language; and

(7) evidence of published procedures for hearing complaints and grievances.

In addition to conducting reviews, the Texas Education Agency staff representatives check complaints of discrimination made by a citizen or citizens residing in a school district where it is alleged discriminatory practices have occurred or are occurring.

Where a violation of Title VI of the Civil Rights Act is found, the findings are reported to the Office for Civil Rights, Department of Health, Education and Welfare.

If there is a direct violation of the Court Order in Civil Action No. 5281 that cannot be cleared through negotiation, the sanctions required by the Court Order are applied.

### TITLE VII, CIVIL RIGHTS ACT OF 1964; EXECUTIVE ORDERS 11246 AND 11375; TITLE IX, 1973 EDUCATION AMENDMENTS; REHABILITATION ACT OF 1973 AS AMENDED; 1974 AMENDMENTS TO THE WAGE-HOUR LAW EXPANDING THE AGE DISCRIMINATION IN EMPLOYMENT ACT OF 1967; AND VIETNAM ERA VETERANS READJUSTMENT ASSISTANCE ACT OF 1972 AS AMENDED IN 1974.

It is the policy of the Texas Education Agency to comply fully with the nondiscrimination provisions of all federal and state laws and regulations by assuring that no person shall be excluded from consideration for recruitment, selection, appointment, training, promotion, retention, or any other personnel action, or be denied any benefits or participation in any programs or activities which it operates on the grounds of race, religion, color, national origin, sex, handicap, age, or veteran status (except where age, sex, or handicap constitute a bona fide occupational qualification necessary to proper and efficient administration). The Texas Education Agency makes positive efforts to employ and advance in employment all protected groups.

Texas Education Agency
Austin, Texas
CU6 370 07
Spring 1987